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Spatial and Temporal Variations in Community Structure of the Demersal Macrofauna of a Subtropical Estuary (Louisiana).

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SPATIAL AND TEMPORAL VARIATIONS IN COMMUNITY STRUCTURE OF THE DEMERSAL MACROFAUNA OF A SUBTROPICAL ESTUARY

A Dissertation

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in

The Department of Zoology and Physiology

by
Thomas C. Shirley
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December 1982

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GLOSSARY OF TERMS

Biocoenotic	-	Pertaining to or oriented towards the biotic assemblage
Biotopic	-	Pertaining to or oriented towards the habitat
Community	-	A group of organisms occurring in a particular environment, presumably interacting with each other and with the environment, and separable by means of ecological survey from other groups (Mills, 1969)
Constancy	-	A measure of ubiquity of a species within a community or habitat
Diversity value	-	Any of numerous statistics derived from information theory (Shannon and Weaver, 1962), usually incorporating both species richness and equitability; D, H', H" and d are common diversity statistics.
Dominance	-	An expression of the degree to which the more important species have appropriated the potential niche space of subordinate species
Equitability	-	The distribution of individuals among species
Evenness	-	Equitability or J'
Fidelity	-	Degree to which a species is restricted to a particular community or habitat
Organization	-	The assessment of functional relationships between entities. Measures of interaction, predator-prey relations, energy flow, feeding rates, etc., are measures of organization.
OTU	-	Operational taxonomic unit; an entity, species, assemblage, station or habitat being analyzed by similarity-disimilarity measures or cluster analysis
Periodicity	-	Changes in abundance of species or OTU's with time
Species richness	-	The number of species present in a sample or community
Standardization	-	Alteration to attribute scores of entities which

depend on some property of the array of scores being considered. The conversion of attribute scores to percent of the array is a simple standardization.

Structure - Description of the arrangement of individuals among distinguishable categories (Watling, 1975)

Vitality - Degree to which a species completes its life cycle within a community

Transformation - Alterations to attribute scores of entities without reference to the range of scores within the population as a whole. Conversion of meristic data to binary form (presence/absence) is the simplest transformation.

ABSTRACT

Epibenthic (trawlable) macrofauna and hydrographic variables were sampled at ten stations in the Calcasieu estuary, Louisiana, from June, 1974, through February, 1976. The 100 otter trawl samples collected contained 32,221 individuals belonging to 63 invertebrate and 68 fish species. The 10 most abundant fish and invertebrate species represented 95.3 and 90.0%, respectively, of the total number of individuals collected. Seasonal variation in numbers of species and individuals were similar, with significant increases in number of species during spring and early summer months.

Numerical classification was used to analyze spatial and temporal patterns of utilization of the estuary and to examine correlates of demographical variation and assemblage structure. Eight site groups and seven species groups were allocated by normal and inverse analyses, respectively. Four of the site groups were seasonally restricted, two were habitat restricted and two were both habitat and seasonally restricted. Nodal analyses identified patterns of constancy and fidelity, with spatial and temporal partitioning of the estuary by the species groups. Biotic interactions were implied by separation of congeners or closely related species into different species groups having separate centers of distribution. Diversity and evenness values, although not utile in assessing areal and seasonal patterns of fluctuations in assemblages, did delimit structural differences in closely related species groups.

A relatively straight, deep ship channel extended the length of the

estuary and had a dominant influence on hydrography by permitting intrusion of high salinity water. A salt water wedge, often with distinct haloclines and thermoclines, was observed at all channel stations. Salinities varied from 0.8 to 33.0 $^{o}/oo$ and temperature ranged from 9.5 to 32.7 °C in the estuary over the duration of the study. Tidal movements and seasonal variations in river discharge rates caused large temporal variations in salinity and temperature at each station. Percent oxygen saturation of channel bottom waters was inversely related to the distance from the mouth of the estuary. Percent oxygen saturation of the channel during summer months was significantly lower than the rest of the year. Hypoxic conditions at deeper stations during warmer months resulted in defaunation.

INTRODUCTION

Most of the work on marine communities has been with benthos (Stephenson, 1973). The nektonic assemblages are difficult to examine because of problems inherent with sampling motile organisms (Livingston, 1976; McErlean et al., 1973). Not all of the nektonic species can be adequately sampled with a single technique, and many of the larger and faster species or individuals often evade collection devices. Spatial and temporal heterogeneity of the assemblages may not be evident because of the transient nature of many of the component species. Some species are anadromous or catadromous, while many euryhaline nektonic species use different estuarine habitats during different stages of their life cycles.

Despite the problems associated with sampling and analysis, nektonic assemblages that fit the description of Petersen-type communities (Thorson, 1957) have been identified in some estuarine habitats (Subrahmanyam and Coultas, 1980; Weinstein et al., 1980). Estuaries are often viewed as physically controlled environments in which biotic interactions have less important roles than in the open ocean (Sanders, 1968). However, competitive interspecific interactions have been implied to play a role in structuring estuarine nektonic communities (Weinstein et al., 1980). Congeneric or closely related species tended to have either: (1) more spatially allopatric distributions, or (2) temporal partitioning where sympatric distributions occurred. Nektonic assemblages may offer insights of community structure not evident with sedentary benthos, as the motility of the nekton stresses biocoenotic views rather than biotopic views.

An extensive body of literature exists concerning the biology of nektonic organisms in estuaries of the northwestern Gulf of Mexico. Seasonal fluctuations in species abundances have been studied in many of the major estuaries (Darnell, 1958, 1961; Fox and Mock, 1968; Gunter, 1938, 1945, 1967; Gunter and Shell, 1958; Norden, 1966; Perry and Carter, 1979; Perret et al., 1971; Sutkas et al., 1954; Wagner, 1973). Many of the studies have been autecological or were concerned with the variation in demography of populations in relation to environmental variables. Although a few studies have used indices based on information theory as data-reduction aids (Betchel and Copeland, 1970; Copeland and Betchel, 1971; Gallaway and Strawn, 1974), there has been an absence of the use of numerical classification techniques (Boesch, 1977; Clifford and Stephenson, 1975) to examine the attributes of community structure.

Numerical classification techniques and diversity indices are used in this study to examine the community structure of the trawable nektonic assemblages of a subtropical estuary in southwestern Louisiana, U.S.A. The utility of the different techniques in assessing spatial and temporal variations in the structural attributes of the assemblages are compared. Nodal analysis is used to examine the constancy and fidelity of the species groups within site groups. The species compositions and distributional patterns of the assemblages are related to habitat and hydrographic variables.

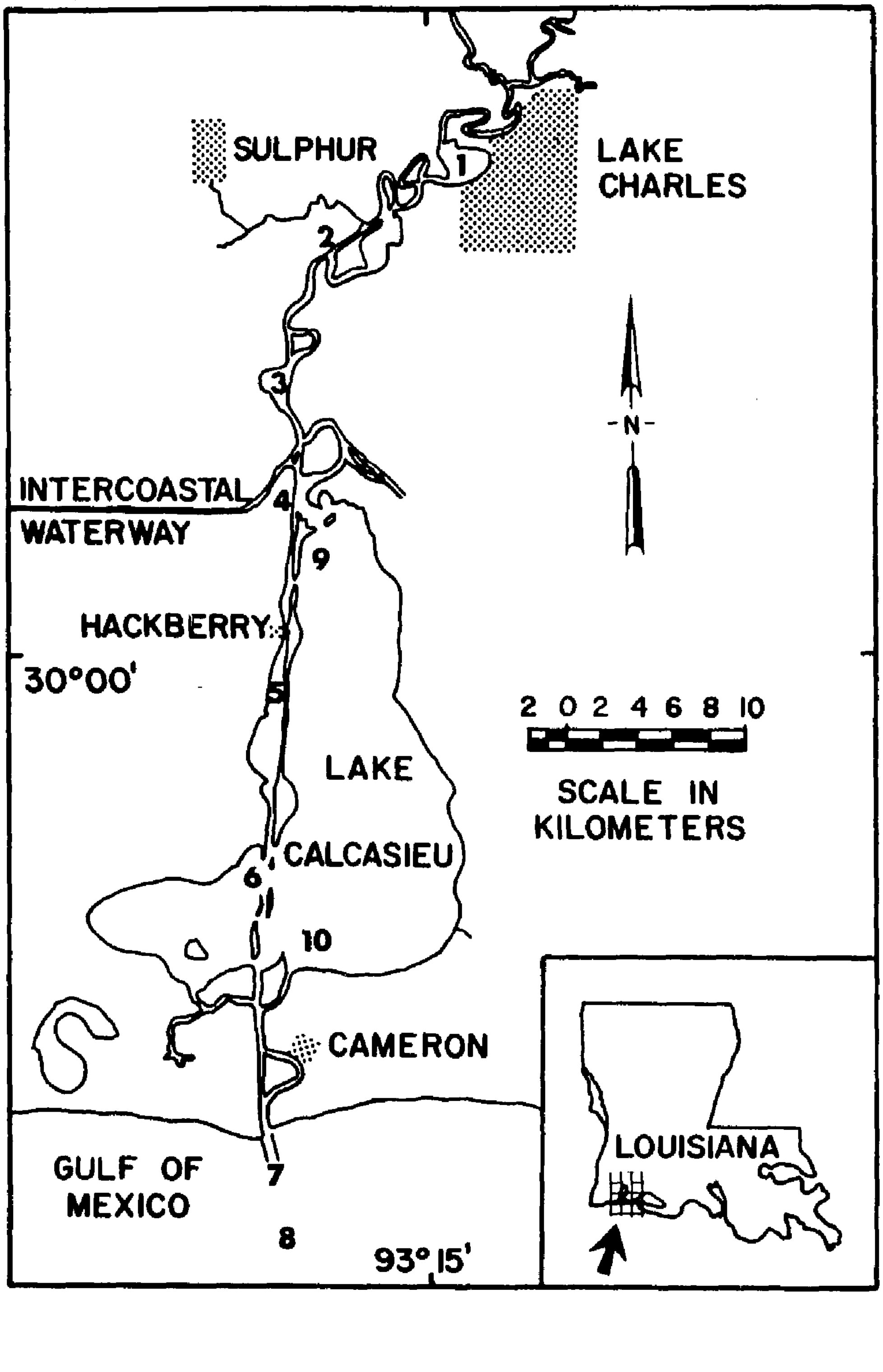
MATERIALS AND METHODS

The Study Area

The Calcasieu River is the fifth largest river in Louisiana in terms of average annual discharge volume (Barret, 1970) and drains a basin of approximately 10,000 km^2 (Sloss, 1971). It originates in Vernon Parish, Louisiana, and follows a southerly course for a distance of 215 miles. At Lake Charles, the river becomes a salt water system subject to tidal variation. A salt water barrier divides the upper and lower basins, to prevent salt water intrusion into the upper reaches of the river where water withdrawals for irrigation are made (U. S. Army Corps of Engineers, 1976). The estuarine portion of the basin supports extensive shrimp, crab, fish and oyster commercial and sport-fisheries. The estuary consists primarily of the Calcasieu Ship Channel and four shallow lakes situated along the old river course (Figure 1). The lakes, their area and average depth, from north to south are: Lake Charles, 4.5 km^2, 2.6 m; Lake Prien, 3.9 km^2, 1.6 m; Moss Lake, 2.2 km^2, 1.0 m; and Lake Calcasieu, 214 km^2, 1.3 m (Barret, 1971). The average depths of the lakes belie the maximum depths, e. g., a 17.0 m depth was recorded during a sampling trip in Lake Charles.

Dredging projects beginning in the early 1900's (R. Vick, Army Corps of Engineers, personal communication) have greatly modified the natural river course from Lake Charles to the mouth of the river at the Gulf of Mexico. The Ship Channel extends from the Port of Lake Charles to 38 km seaward of the jetties at Cameron, and is maintained by periodic dredging to 61 m width and 12.8 m depth (U. S. Army Corps of

Figure 1. Map of the Calcasieu estuary showing sampling stations.


SULPHUR
LAKE
CHARLES
1
2
3
N
INTERCOASTAL
WATERWAY
4
9
HACKBERRY
30°00'
5
2 0 2 4 6 8 10
SCALE IN
KILOMETERS
LAKE
CALCASIEU
6
10
CAMERON
GULF OF
MEXICO
7
8
93° 15'
LOUISIANA

Engineers, 1976). The straightness and depth of the channel have permitted salt water intrusion further into the system which has greatly changed the biota. Perhaps the most obvious evidence of salt water intrusion is the dead bald cypress swamps found along tributaries near Lake Charles (Penfound, 1952; personal observation). Most of the estuary is bordered by brackish and intermediate marshes (Chabreck *et al.*, 1968; Chabreck, 1972).

Eight stations along the Calcasieu Ship Channel were selected which were thought to encompass the habitat variety of the estuary. An additional station was added in northern Lake Calcasieu in December, 1974, and a tenth in southern Lake Calcasieu in January, 1975 (Table 1). Sampling began in June, 1974, and continued through February, 1976. Samples were collected monthly with the exception of July, August, September or November of 1974 and in January, August, October or November of 1975. Samples were taken from the Wahoo III, a vessel of the Louisiana Department of Wildlife and Fisheries. Two days were required for the collection of samples each month.

Hydrographic Data

Hydrographic data were collected from three positions at each station adjacent to the ship channel (Stations 2, 3, 4, 5, 6, 7): a surface position on the side or apron of the channel, another directly below on the apron bottom if the water depth was greater than 1.0 m, and a third position on the bottom in the center of the ship channel. Those stations with level bottoms (Stations 1, 8, 9, 10) were sampled at two positions: on the surface and on the bottom, if the water depth exceeded 1.0 m.

Table 1. List of sampling stations with location, longitude and lattitude and distance from Calcasieu Pass. A negative sign (-) before the distance indicates that the station is offshore. "NB" indicates that no buoy was present.

Station Number	Location	Longitude & Lattitude	Buoy Number	Distance (km)
1	Lake Charles	30°14'N, 93°14'W	NB	57.6
2	Ship Channel south of Bayou D'Inde	30°12'N, 93°17'W	108	48.8
3	Ship Channel at Moss Lake	30°06'N, 93°20'W	100	40.0
4	Ship Channel at Mud Pass	30°04'N, 93°20'W	88	34.0
5	Ship Channel south of Hackberry, La.	29°59'N, 93°20'W	78	24.0
6	Ship Channel	29°53'N, 93°20'W	66	13.8
7	Ship Channel, mouth of jetties	29°45'N, 93°20'W	48	-0.4
8	Ship Channel	29°42'N,, 93°20'W	36	-5.6
9	Lake Calcasieu, north end	30°01'N, 93°18'W	NB	30.4
10	Lake Calcasieu, south end	29°51'N, 93°19'W	NB	11.2

Conductivity, temperature, and salinity were measured with a Beckman electrodeless *in situ* salinometer in water less than 6.0 m deep. Tidal currents and positioning uncertainty made use of the salinometer in deeper water difficult. At the deeper positions, water was collected in a 9.0 liter Van Dorn Water Sampler and temperature was measured with a thermometer mounted in the sampler. Conductivity was measured with a Lab-Line Lectro Mho Meter MC-1 Mark IV and salinity was measured with an AO Goldberg T/C Refractometer. Calibration of salinity on the Beckman salinometer was performed with seawater of known salinity as determined with a Precision System Osmometer. Salinity classification used in this study follows the Venice system (Carriker, 1967): limnetic (< 0.5 $^{o}/oo$), oligohaline (0.5 - 5 $^{o}/oo$), mesohaline (5 - 18 $^{o}/oo$), polyhaline (18 - 30 $^{o}/oo$) and marine (> 30 $^{o}/oo$). Conductivity was standardized against the Lab-Line Lectro Mho Meter. Standard potassium chloride solutions were used to construct a standard curve for the correction of the readings of the latter instrument (American Public Health Association, 1971).

Water samples were collected at all positions using the Van Dorn water sampler. Dissolved oxygen concentrations were determined by a modified Winkler method (Strickland and Parsons, 1972). Titrations were completed in the laboratory within 48 hours of collection. Oxygen concentration values were converted to percent saturation to compensate for the effects of temperature and salinity on oxygen solubility.

Discharge rates used for correlations were averages for the three week period prior to the collection date and were obtained from a U. S. Geological Survey hydrological station at Kinder, Louisiana (U. S.

Department of the Interior, 1974, 1975 and 1976). A three week period was selected because it was the shortest period between successive collections. The actual residence time of water masses in the system is not known and is surely not constant either temporally or spatially. The discharge rates represent only the riverine part of the system and do not consider drainage of tributaries into the estuarine portion below the hydrological station.

Biological Samples

A single 10 min tow at a speed of 2-2.5 knots was made at each station with a 5 m (16 foot) otter trawl (1.9 cm mesh wing and body; 0.6 cm mesh liner in cod end). All samples were taken during daylight hours. All fish and larger invertebrates (>1.0 cm) were placed in plastic bags and frozen; smaller specimens were preserved immediately in 10% buffered formalin. Specimens were identified, measured and weighed at a later date.

Sediments

Two sediment samples were collected from each station with a Phleger gravity corer. A 25 g sample from the upper 15 cm of the sediment was soaked in a 4% sodium hexametaphosphate solution and separated into the sand and silt-clay fraction by wet seiving through a 62 μm seive (Buchanan and Kain, 1971). The sand fraction was then further graded by dry seiving through a standard Wentworth seive series, incremented in one φ units, with a Ro-Tap mechanical seive shaker. The individual fractions were weighed with a Mettler balance to determine percentage composition. The clay-silt particle distribution was determined by standard pipette analysis following the procedures of Folk

(1966). Cumulative sediment ϕ particle size classes of -1.0 to 8.0 ϕ were plotted as cumulative probability and median diameter (Md ϕ) and standard deviation ($\sigma\phi$) were computed using equations given by Inman (1952). Percentages of sand, silt and clay at each station were plotted on a tertiary diagram and the sediment characterized by the nomenclature of Shepard (1954).

Statistical Analyses

The Statistical Analysis System, SAS, (Barr et al., 1979) was used extensively for data analyses. Correlation coefficients (r) were determined between species distributions and all measured hydrographic and edaphic variables. The significance of the correlation between salinity at the various sampling times and distance from the mouth of the estuary was tested using linear regression. A one-way classification of the analysis of variance was used to test the variation among percent oxygen saturation of water by month. A further partitioning of the variation was tested by orthogonal comparisons. Student's t test was used to test significant differences between means in some cases. For all analyses, test statistics beyond the 95% region of acceptance were considered significant ($P<0.05$) and statistics falling outside of the 99% region of acceptance were considered highly significant ($P<0.01$). All means appear as mean ± standard error.

Numerical classification of biotic data was completed using a package of computer programs by Bloom et al., (1976) adapted to the LSU System Network Computer Center. Data were transformed with simultaneous double standardization (Boesch, 1973, 1977). The resemblance (similarity - dissimilarity) measure used was the Canberra metric.

It is a classification strategy that is less biased towards dominant species that are ubiquitous because it represents the sum of a series of fractions. It includes both qualitative and quantitative criteria. It is expressed as:

$$D_{1,2} = 1/n \sum_{i}^{n} \frac{|x_{1i}-x_{2i}|}{(x_{1i}+x_{2i})}$$

when n is the number of attributes (species) and x_{1i} and x_{2i} are the values of the j^{th} attribute for any pair of entities (sites). When applied to binary data, the measure reduces to the Jaccard coefficient (Boesch, 1977). The Canberra metric measure has been used primarily by the associates of the Canberra (Australia) school of numerical classification (Stephenson et al., 1972), although its use has been advocated (Boesch, 1973, 1977).

An agglomerative, hierarchial, combinatorial clustering strategy was used to optimally group individuals into a dendrogram based on their relationships from the symmetrical inter-individual dissimilarity matrices. The flexible-sorting strategy (Lance and Williams, 1967) was used with the cluster intensity coefficient, (β), set at the now conventional value of -0.25 (Boesch, 1977). The strategy is space-dilating and intensely clustering.

The resemblance matrix was computed using both Q analysis, or normal analysis, with sites (collections) as individuals, and species as attributes and with R analysis, or inverse analysis, with species as individuals and sites as attributes. Relating normal and inverse classifications has been recommended as a routine post-clustering analysis by Boesch (1977). The methodology has been termed "nodal analysis" by Williams and Lambert (1961). The ecological interpretation of the two-way tables permits identification of misclassifications and assists in reallocations. The degree of collection group and species group coincidence from the two-way tables is expressed using the concepts of constancy and fidelity.

Constancy is a measure of the ubiquity of a species group, or the proportion of the number of occurrences of the species in a species group to the total possible number of occurrences. The algebraic expression of constancy is: $C_{ij} = a_{ij}/(n_i n_j)$, where a_{ij} is the actual number of occurrences of species group i in collection group j and n_i and n_j are the number of entities in the respective groups (Boesch, 1977).

Fidelity is the degree to which a species group prefers or is restricted to collection sites. A simple index of fidelity was expressed by Boesch (1977) as being the constancy of species in a collection group compared to the constancy over all collections. The terms used in the constancy index above can be used to algebraically define fidelity: $F_{ij} = (a_{ij} \Sigma_j n_j)/n_j \Sigma_j a_{ij})$. Fidelity will be unity when the constancy of a species group at a collection site is the same as its constancy at all collection sites. Higher values (>2) imply a strong habitat preference, while low values (<1) are indicative of habitat avoidance.

A plethora of indices using the vernacular of information theory (Shannon and Weaver, 1962) and thermodynamics have been offered as a panacea to ecological evaluation. Although all schemes consider the numerical composition by species of quantitative samples, and are measures of community structure, the species identities and their respective contributions to the structure of the community are lost. Diversity was calculated as the Shannon-Weiner information (Pielou, 1974):

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i,$$

where p_i is the proportion of the community that belongs to the i^{th} species ($p_i = {}^{N}i_{/N}$, where N_i is the number of individuals of the i^{th} species and N is the total number of individuals). Evenness (J'), the distribution of the individuals among the different species, was calculated as $J' = H'/\log_2 S$, where S is the number of species in the collection and H' is the Shannon-Weiner information function.

The probability of interspecific encounter (P.I.E. or Δ_1), a non-diversity index with biological meaning (Hurlbert, 1971), was calculated as

$$\Delta_1 = \left(\frac{N}{N-1}\right)\left(1 - \sum_{i=1}^{s} \left(\frac{N_i}{N}\right)^2\right),$$

where N_i = number of individuals in the i^{th} species and N= total number of individuals. Δ_1 is the probability that an encounter between two members of a community will be interspecific, or from another view, the probability that any two randomly selected individuals of a community will be of different species.

RESULTS

Hydrographic Data

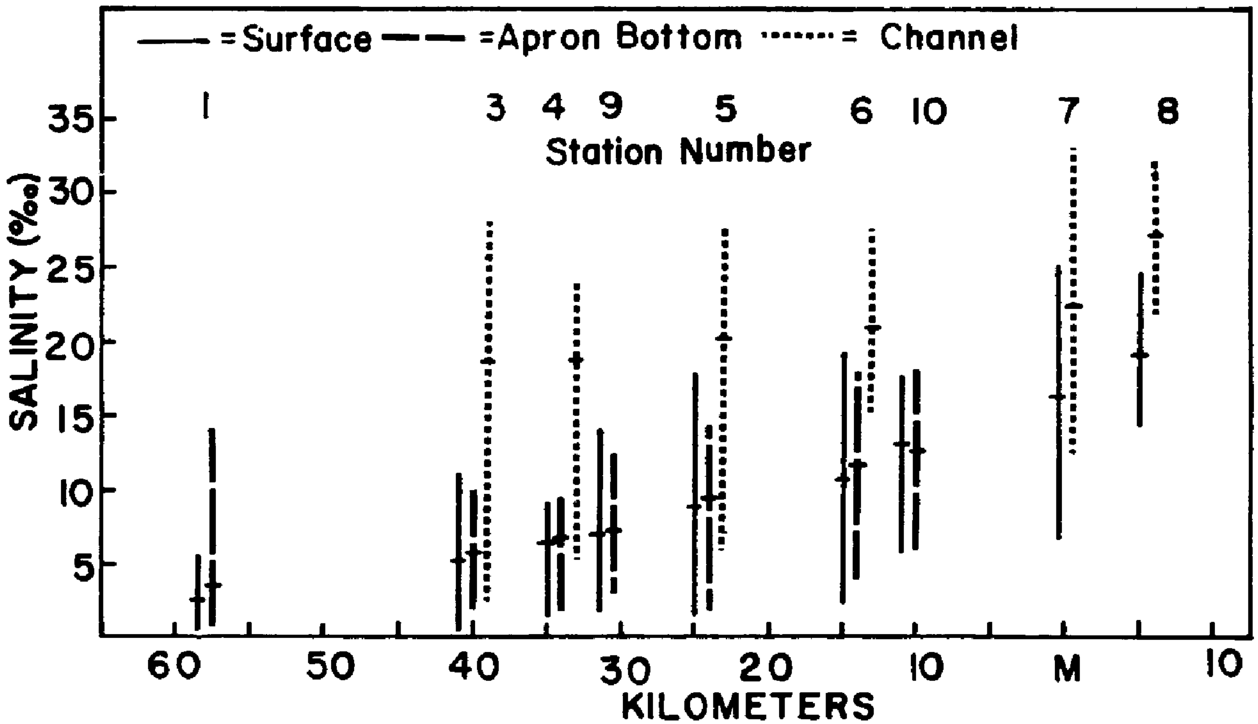
A large temporal variation in salinity occurred at each station due to the interactions of tidal movements of a salt-water wedge and the seasonal variation in river discharge rates, but salinities generally increased seaward (Figure 2). A complete listing of salinity data by station is included in Appendices 1-10.

Surface salinities were generally inversely related to the Calcasieu River discharge rates (Figure 3). The salinity of the bottom waters was less indicative of the river discharge rates (Figure 4). The correlation coefficients between salinity measurements and discharge rates were not significant, except for surface salinity at station five, which had a significant negative correlation.

On most sampling dates a salt-water wedge was observed at stations adjacent to the 12.8 m deep, relatively straight ship channel. The wedge was observed as far up the estuary as station two, 48.8 km from the river mouth, where in December, 1974, surface salinity was 2.2 ^{o}/oo and bottom salinity was 24.5 ^{o}/oo. Distinct vertical stratification was present the same month in Lake Charles, with 1.4 ^{o}/oo S in surface waters and 13.9 ^{o}/oo S in bottom waters of 2 m depth. The wedge was not present during a period of high river discharge rates in June, 1975, and April, 1975, which was perhaps a low tide period.

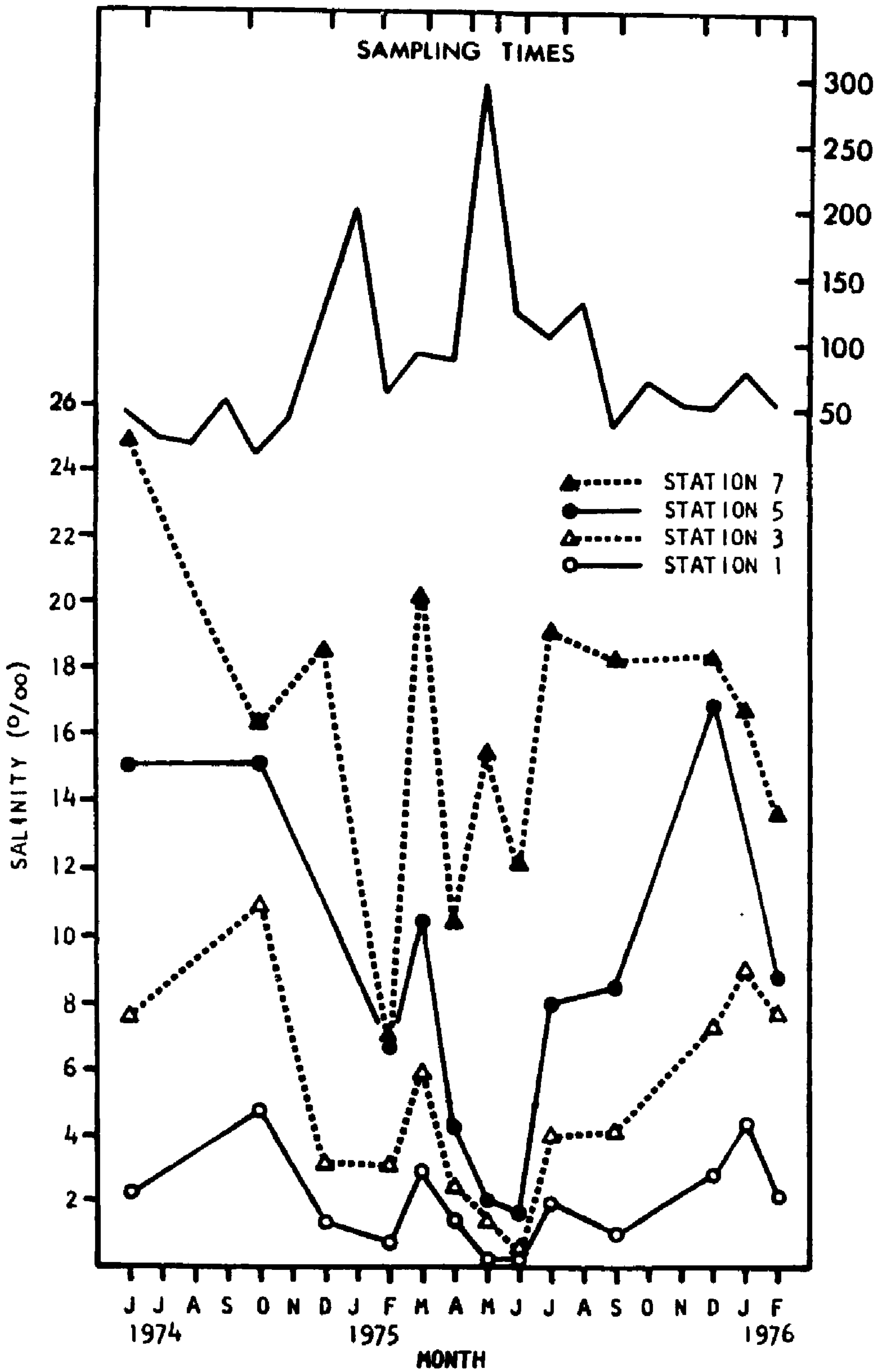
The horizontal salinity gradient within the estuary was relatively uniform, with salinities increasing seaward. The salinity of the sta-

Figure 2. Means and ranges of salinity by station and sampling position. Means are indicated by horizontal bars. Stations are arranged by distance from the mouth of the estuary (M).



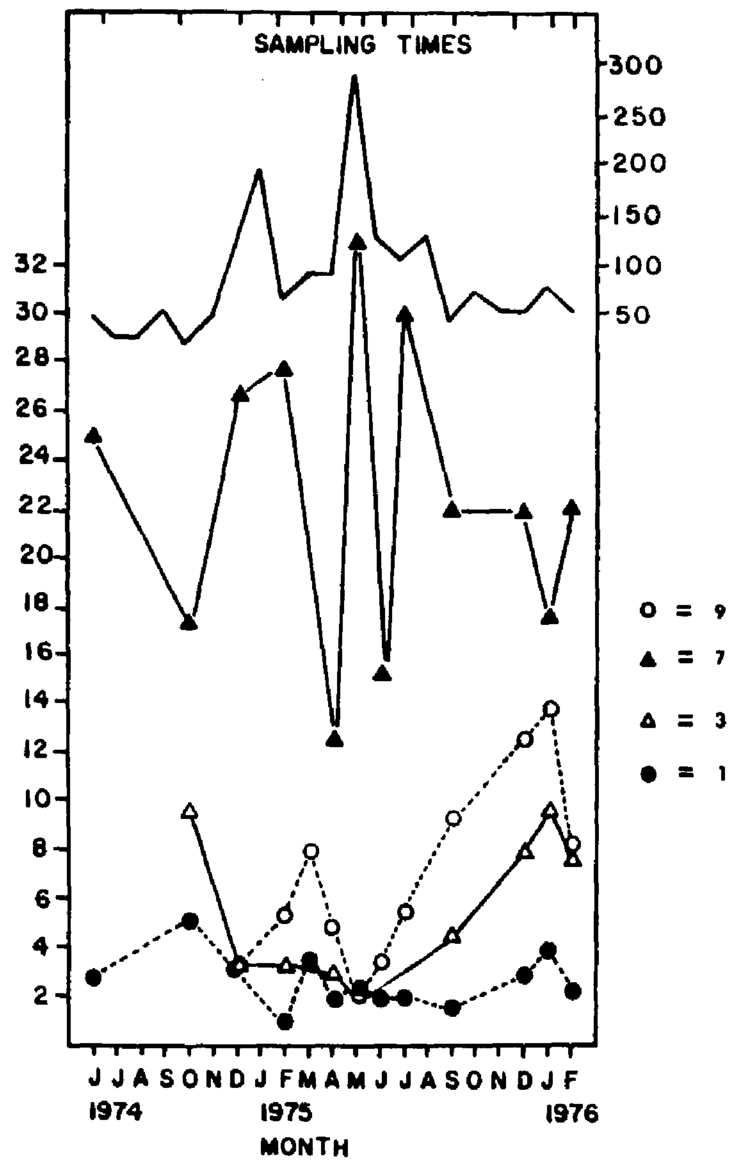
=Surface
=Apron Bottom
= Channel
1 3 4 9 5 6 10 7 8
Station Number
SALINITY (‰)
35
30
25
20
15
10
5
60 50 40 30 20 10 M 10
KILOMETERS

Figure 3. Monthly surface salinities for stations 1, 3, 5 and 7 from June, 1974, to February, 1976, with the three-week average river discharge rate prior to collection dates.



SAMPLING TIMES
DISCHARGE (M^3/SEC)
300
250
200
150
100
50
SALINITY (°/oo)
26
24
22
20
18
16
14
12
10
8
6
4
2
STATION 7
STATION 5
STATION 3
STATION 1
J J A S O N D J F M A M J J A S O N D J F
1974
1975
1976
MONTH

Figure 4. Monthly bottom salinities from stations 1, 3, 7 and 9 from June, 1974, to February, 1976, with the three-week average river discharge rate prior to collection dates.


SAMPLING TIMES
300
250
200
150
100
50
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
O = 9
▲ = 7
△ = 3
● = 1
J J A S O N D J F M A M J J A S O N D J F
1974
1975
1976
MONTH

tions near the mouth of the estuary were abruptly higher than those stations up estuary, however, during periods of high river discharge, as in the summer of 1975. Despite the temporal variations at each station, a highly significant correlation ($r=0.79$, $P<0.001$) exists between the pooled salinity values by station and distance from the mouth of the estuary. This relationship can be described by the equation $y = 21.44 + (-0.34)x$, where x = distance in km and y = salinity in $^{o}/oo$).

The deepest positions, on the channel bottom stations had the smallest temperature range, from 10.4 to 29.8 °C. Apron bottom temperatures had a slightly wider range, 9.9 to 30.4 °C and surface waters had the largest range, from 9.5 to 32.7 °C (Figure 5, Table 2).

The distinct thermoclines and haloclines present in channel stations and the contrasting lack of vertical stratification in the shallow waters of Lake Calcasieu are evident in combined temperature-salinity plots (Figure 6). The horizontal elongation of the bottom water polygon in comparison to the surface water polygon at station 1 demonstrates the influence of the channel waters. The wide ranges of salinity between adjacent sampling periods are also evident in the channel stations.

A hot water discharge from an industrial complex located immediately north of station three was evident in water temperature data. An average increase of 1.5 °C in surface waters and 2.4 °C in channel bottom waters was present between station one, above the complex, and station three, below the complex. The largest increase, 3.2 °C, in surface waters was during the summer months, June and July, 1975, when the air-water temperature differential was at a minimum. The

Figure 5. Means and ranges of water temperatures by sampling period.

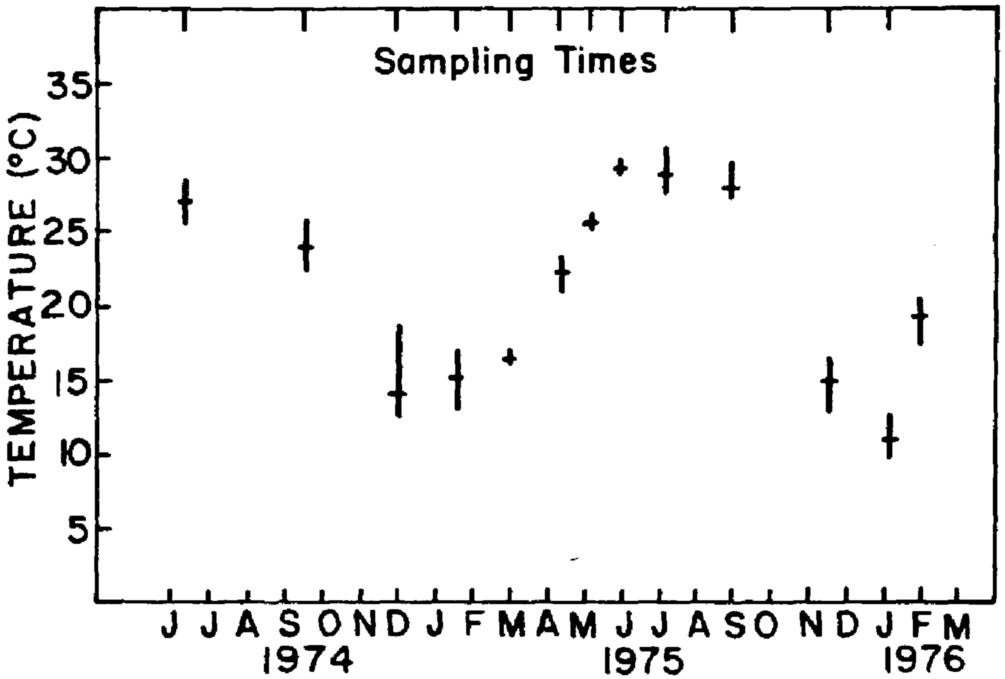
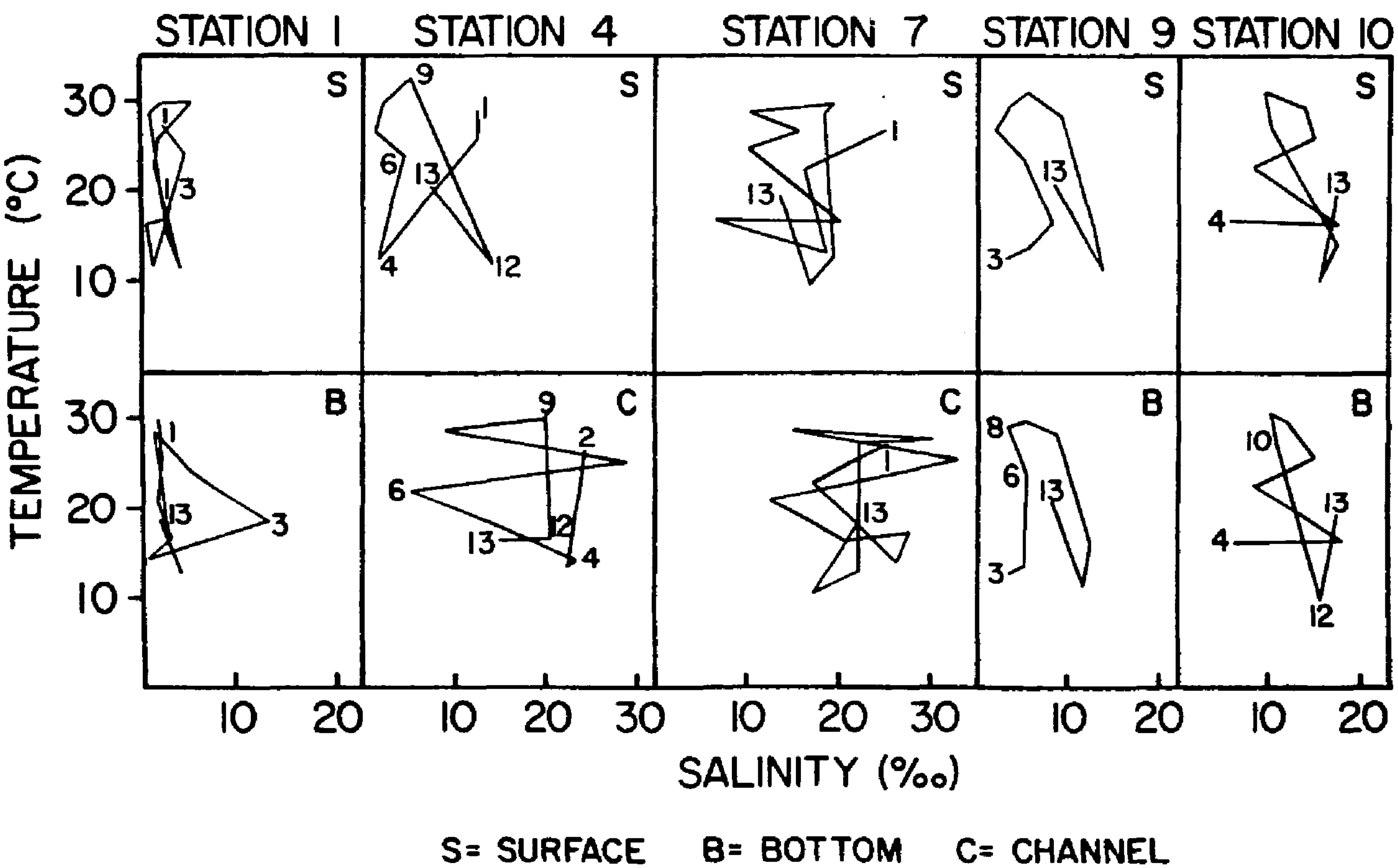

Sampling Times
TEMPERATURE (°C)
35
30
25
20
15
10
5
J J A S O N D J F M A M J J A S O N D J F M
1974
1975
1976

Table 2. Average water temperature with ranges by station and position. Arrangement of stations in table is in accordance with distance from head of estuary. NA = Position not applicable at this station.

Station		Temperature (°C) Surface	Apron Bottom	Channel bottom
1	Mean	21.3	21.8	NA
	Range	29.9-11.4	29.8-12.9	
2	Mean	21.7	NA	22.3
	Range	27.1-12.1		28.7-13.4
3	Mean	22.8	20.3	24.7
	Range	32.7-12.8	29.6-12.3	29.8-15.3
4	Mean	22.4	22.5	20.7
	Range	32.2-11.7	29.2-12.8	29.8-13.5
9	Mean	20.7	20.4	NA
	Range	30.7-11.1	29.7-11.3	
5	Mean	22.6	19.3	23.3
	Range	29.3-13.7	25.4-13.8	29.8-14.4
6	Mean	20.6	20.4	20.6
	Range	29.4-10.0	29.2-9.9	28.6-10.4
10	Mean	21.1	21.9	NA
	Range	30.9-10.0	30.4-9.8	
7	Mean	21.0	NA	20.0
	Range	29.4-9.5		27.9-10.6
8	Mean	22.9	NA	22.1
	Range	30.8-16.2		27.6-16.5

Figure 6. Temperature-salinity polygons for surface (S) and lake bottom (B) or channel (C) for stations 1, 4, 7, 9 and 10. Numbers are sampling periods.


STATION 1
STATION 4
STATION 7
STATION 9
STATION 10
S
B
C
TEMPERATURE (°C)
SALINITY (‰)
10
20
30
S= SURFACE B= BOTTOM C= CHANNEL

difference in bottom water temperatures between stations one and three was as large as 5.4 °C in December, 1975. The temperature plume was not dissipated until the water had reached station five or six, 16 to 26 km seaward of the discharge. The temperature differential between the plume and the ambient waters was visible in the form of a vapor trail during winter months at times when wind speeds were low.

No spatial pattern was found for oxygen content or percent saturation for any position. The dissolved oxygen levels in the apron and lake bottom water had the greatest variation, from 0.00 mg O_2/l at station one in October, 1974, to 9.98 mg O_2/l at station nine in January, 1976. The channel bottom waters varied from 0.00 mg O_2 at station two in June, 1974, and station eight in July, 1975, to 9.91 mg O_2/l at station seven in December, 1975. The surface waters had the smallest range of oxygen content, from 3.49 mg O_2/l at station one in October, 1974, to 10.19 mg O_2/l at station nine in January, 1976. The means and ranges are presented by station and position for dissolved oxygen content (Figure 7) and percent oxygen saturation (Figure 8). The means and ranges of oxygen content and percent saturation by month and position are listed in Table 3.

No spatial trends in percent oxygen saturation were found for the surface or apron and lake bottom waters. Percent oxygen saturation of the channel bottom waters was inversely related to the distance from the mouth of the estuary for all months except December, 1975, when all waters were supersaturated. Temporal variation in percent saturation was significant (ANOVA $P<0.05$) for surface waters and highly significant ($P<0.01$) for channel bottom waters, but insignificant for apron or lake

Figure 7. Means and ranges of dissolved oxygen content (mg O_2/l) by station and position from June, 1974, to February, 1976. WQC is the Louisiana water quality criteria (Louisiana Stream Control Commission, 1968).

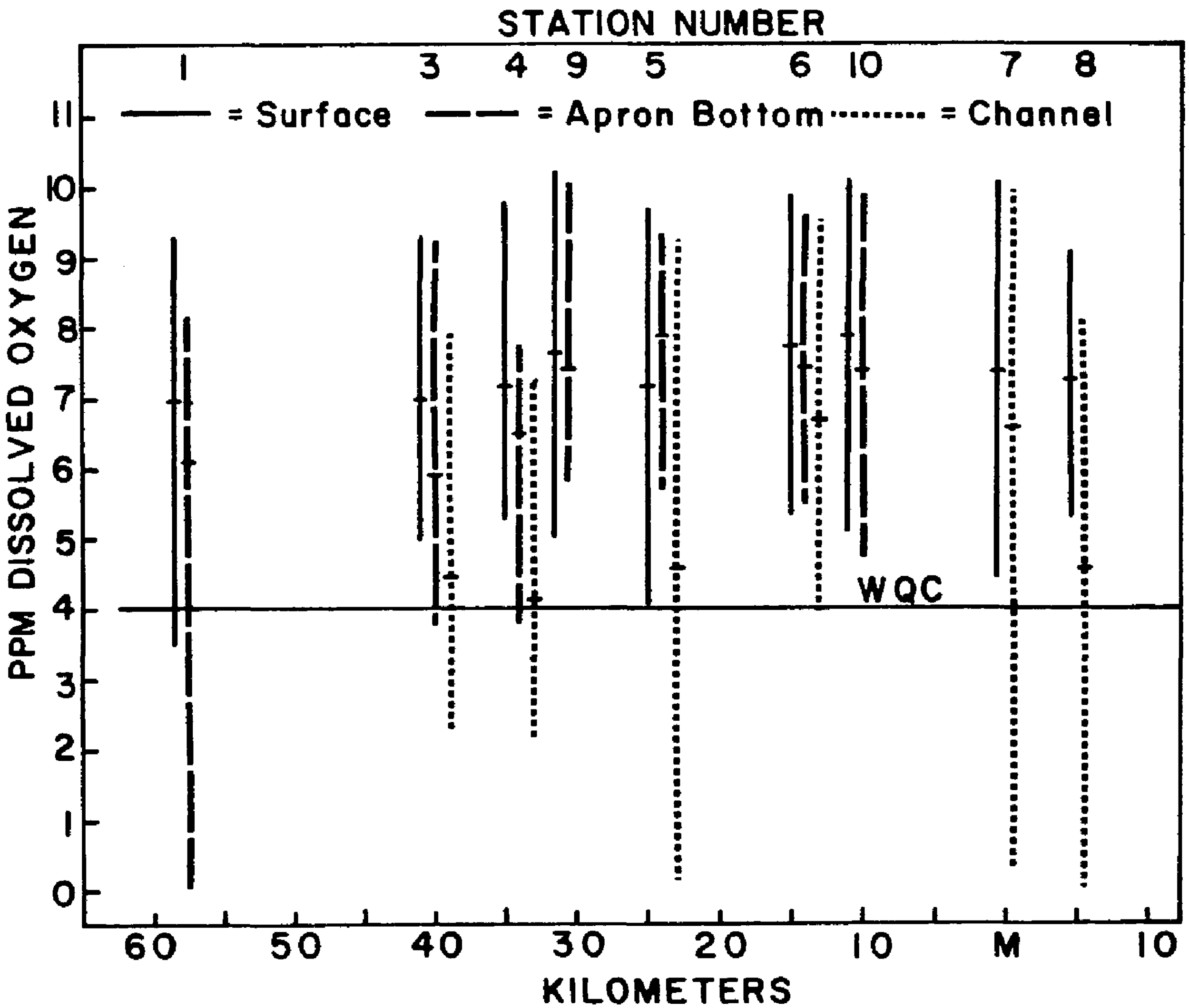
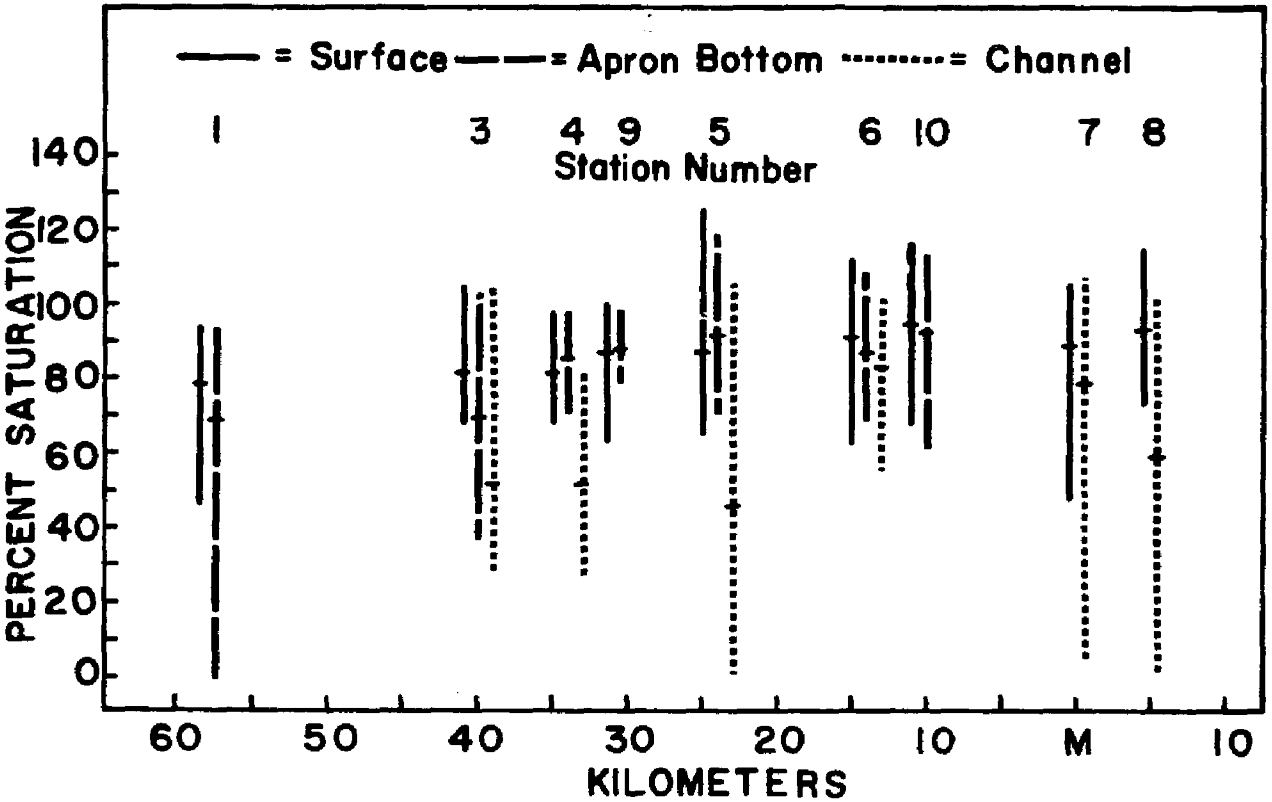

STATION NUMBER
1
3
4
9
5
6
10
7
8
— = Surface
— — = Apron Bottom
········ = Channel
WQC
PPM DISSOLVED OXYGEN
0
1
2
3
4
5
6
7
8
9
10
11
60
50
40
30
20
10
M
10
KILOMETERS

Figure 8. Means and ranges of percent oxygen saturation by station and position from June, 1974, to February, 1976.



= Surface
= Apron Bottom
= Channel
1 3 4 9 5 6 10 7 8
Station Number
PERCENT SATURATION
140
120
100
80
60
40
20
0
60 50 40 30 20 10 M 10
KILOMETERS

Table 3. Mean dissolved oxygen values and percent saturation values with ranges by month and position.

Month			Dissolved Oxygen ($mg\ O_2/l$)			% Saturation		
			Surface	Apron Bottom	Channel Bottom	Surface	Apron Bottom	Channel Bottom
1974	June	$\bar{X}$	5.58	5.58	2.75	76	73	40
		Range	4.69-6.60	5.88-5.88	0.00-4.59	62 - 86	70 - 76	0 - 66
	October	X	7.35	5.82	6.77	94	74	68
		Range	5.65-9.65	0.00-9.16	3.32-7.21	73-125	0-118	44 - 92
	December	X	7.86	7.35	6.77	76	78	78
		Range	6.04-9.16	6.33-8.37	5.65-8.08	56 - 96	73 - 83	60 - 92
1975	February	X	7.68	7.83	3.44	79	78	43
		Range	4.44-10.1	7.73-7.92	1.93-5.02	47-106	76 - 80	24 - 61
	March	X	9.02	8.62	8.12	100	91	98
		Range	8.42-9.54	8.42-8.81	7.17-8.77	88-105	88 - 94	96-100
	April	X	6.15	6.99	6.57	83	83	77
		Range	5.36-8.23	6.13-8.04	4.88-7.66	63-100	71 - 97	56 - 92
	May	X	5.75	5.00	2.75	74	63	39
		Range	5.00-6.27	2.84-5.68	2.06-3.92	63-100	36 - 71	29 - 55
	June	X	6.48	6.65	5.35	88	90	82
		Range	5.79-7.19	6.19-7.32	3.69-6.89	76 - 97	85 - 93	5 - 82
	July	X	6.57	5.24	1.74	93	89	29
		Range	3.49-8.29	3.39-7.99	0.00-3.30	46-116	45-113	0 - 49
	September	X	6.17	5.76	4.84	86	78	69
		Range	4.06-8.04	3.74-7.11	2.81-6.64	65-109	51 - 96	40 - 95
	December	X	8.66	8.19	8.98	93	88	105
		Range	6.87-10.0	6.50-9.32	7.95-9.91	74-107	70-101	101-107
1976	January	X	9.61	9.13	7.91	89	92	82
		Range	8.56-10.2	7.13-9.98	4.69-9.58	68-100	70-101	54 - 96
	February	X	7.71	7.61	3.19	89	87	50
		Range	6.87-8.54	7.07-8.24	0.10-8.05	80-100	81 - 94	1-101

bottom waters. Further partitioning of the variation by orthogonal comparisons demonstrated that the percent oxygen saturation values for the channel waters for the summer months were highly significantly lower than the values for the rest of the year. No significant variation was found for surface waters when months were grouped into seasons, but oxygen saturation was significantly higher in months of high river discharge (>70 m^3/sec) than in months of low river discharge (<70 m^3/sec).

Sediments

The percent of total sediment belonging to sand, silt and clay, excluding particles larger than sand size, are graphically presented for the permanent sampling stations in a tertiary diagram (Figure 9). Finer sediments predominated throughout the estuary and the sediments of all stations were silts, silty-clays or clayey-silts. The slight amount of temporal variation between summer and winter sampling can be attributed to spatial heterogeneity. A more detailed sediment analysis of Lake Calcasieu was completed by the Louisiana Geological Survey (Perret *et al.*, 1971) and is presented in Figure 10. Their survey also indicated that silty-clays and clayey-silts predominated over most of the lake. A small area consisting primarily of sandy sediments was found at station 10 of this study, the site of an oyster reef complex. Attempts to induce oyster spat settlement by seeding with shell and fill material (White and Perret, 1974) have probably produced several areas in the southern part of the lake whose sediments are different from the indigenous sediments.

Figure 9. Tertiary diagram of sediment sand-silt-clay proportions of the stations shown in Figure 1.

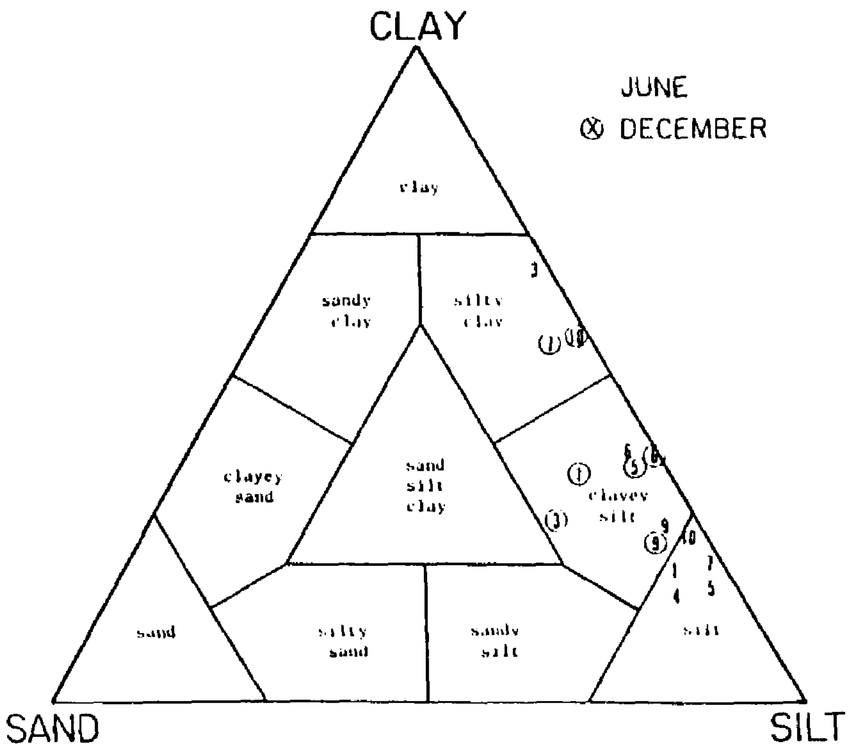
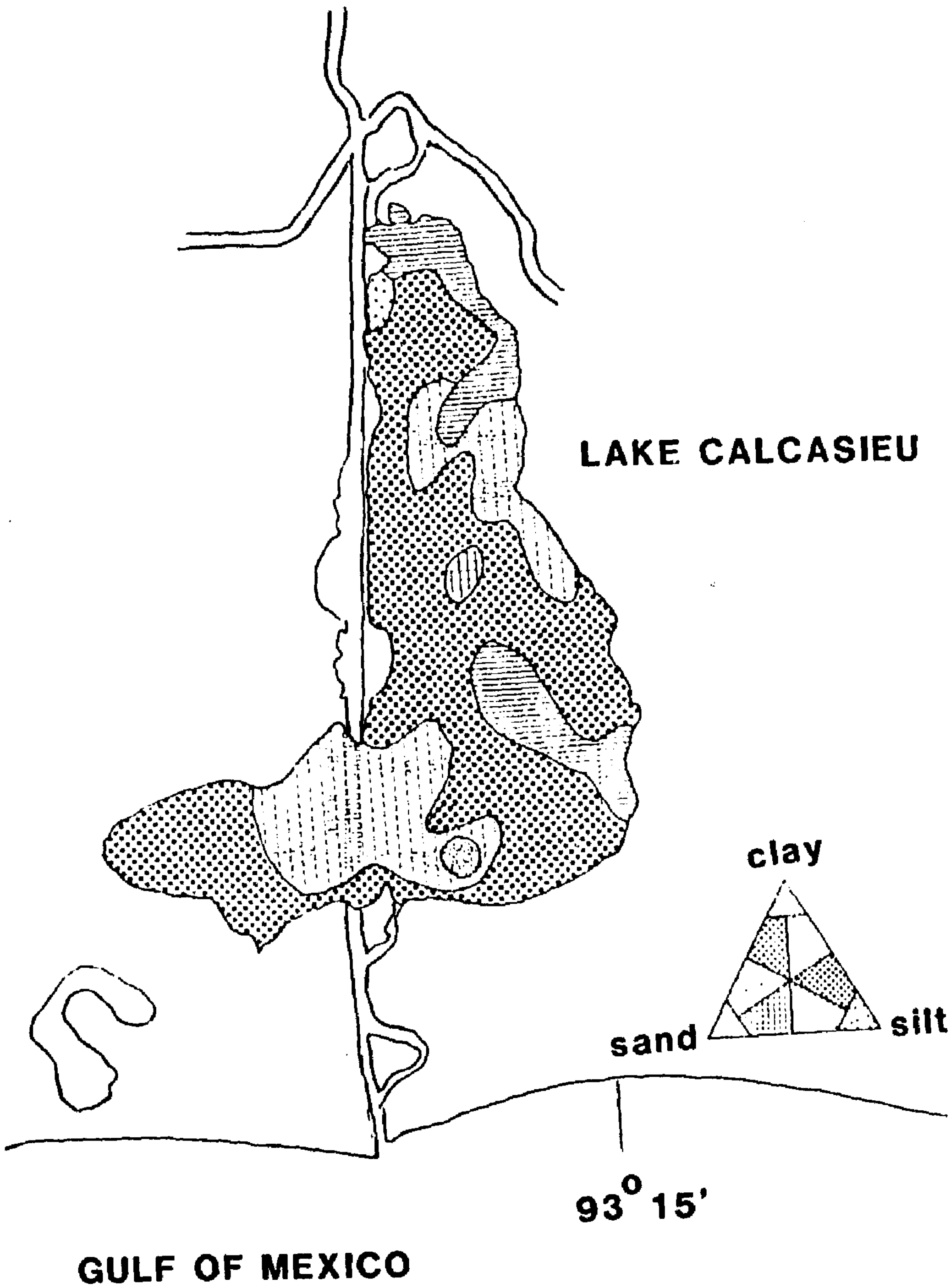

CLAY
JUNE
⊗ DECEMBER
clay
sandy clay
silty clay
clayey sand
sand silt clay
clayey silt
sand
silty sand
sandy silt
silt
SAND
SILT

Figure 10. Sediment distribution in Lake Calcasieu (from Perret *et al.*, 1971).


LAKE CALCASIEU
clay
sand
silt
93° 15'
GULF OF MEXICO

Faunal Data

The 100 trawl samples collected during the study contained 32,221 individuals; 24,881 fish and 7,340 macroinvertebrates. Colonial invertebrates such as ectoprocts and hydroids are not included in analyses but are contained in a complete listing of the 63 invertebrate and 68 fish species identified from trawl samples (Appendix 13).

The ten numerically most abundant fish and epibenthic macroinvertebrate species, their frequency of occurrence, total abundance and percentage of total collections are listed in Table 4. The five most abundant fish species were collected in all sampling periods, with the exception of *Brevortia patronus*, which was not collected in January, 1976, and *Arius felis*, which was absent in December, 1974, and January and February, 1976. The five species were also collected at all stations at some time during the study, with the exception of *Leiostomus xanthurus* which was not collected at station 8.

Five of the ten most abundant fish species belong to the family Sciaenidae. A total of ten sciaenid species were collected, containing 13,366 individuals which comprised 54% of all fish collected.

All of the ten most abundant invertebrate species were natant decapod crustaceans (shrimp) with the exception of the blue crab, *Callinectes sapidus*, the mantis shrimp, *Squilla empusa*, and the oyster worm, *Neanthes succinea*.

The invertebrates were less ubiquitous than the fish. Only the first and fourth most abundant species, *Penaeus setiferus* and *Callinectes sapidus*, respectively, were collected in more than 50% of the samples. Four of the ten most abundant invertebrate species were

Table 4. Rank, total number collected, frequency of occurrence and percentage of total collections for ten most abundant fish and invertebrate species collected by trawling.

FISH

Rank	Species	# individuals	Frequency(%)	% of total
1	Micropogonias undulatus	11206	79	45.0
2	Anchoa mitchelli	6555	79	26.3
3	Brevortia patronus	2831	42	11.4
4	Leiostomus xanthurus	1038	53	4.2
5	Arius felis	708	39	2.8
6	Cynoscion arenarius	515	42	2.1
7	Stellifer lanceolatus	401	16	1.6
8	Chaetodipterus faber	170	23	0.7
9	Polydactylus octonemus	168	10	0.7
10	Larimus fasciatus	133	6	0.5
				Σ 95.3%

INVERTEBRATES

Rank	Species	# individuals	Frequency(%)	% of total
1	Penaeus setiferus	1528	59	26.4
2	Penaeus aztecus aztecus	1203	27	20.8
3	Trachypenaeus similis	852	10	14.7
4	Callinectes sapidus	462	69	8.0
5	Acetes americanus	453	9	7.8
6	Xiphopenaeus kroyeri	264	7	4.6
7	Palaemonetes vulgaris	233	15	4.0
8	Squilla empusa	73	4	1.3
9	Neanthes succinea	72	12	1.2
10	Macrobrachium ohione	66	11	1.1
				Σ 90.0%

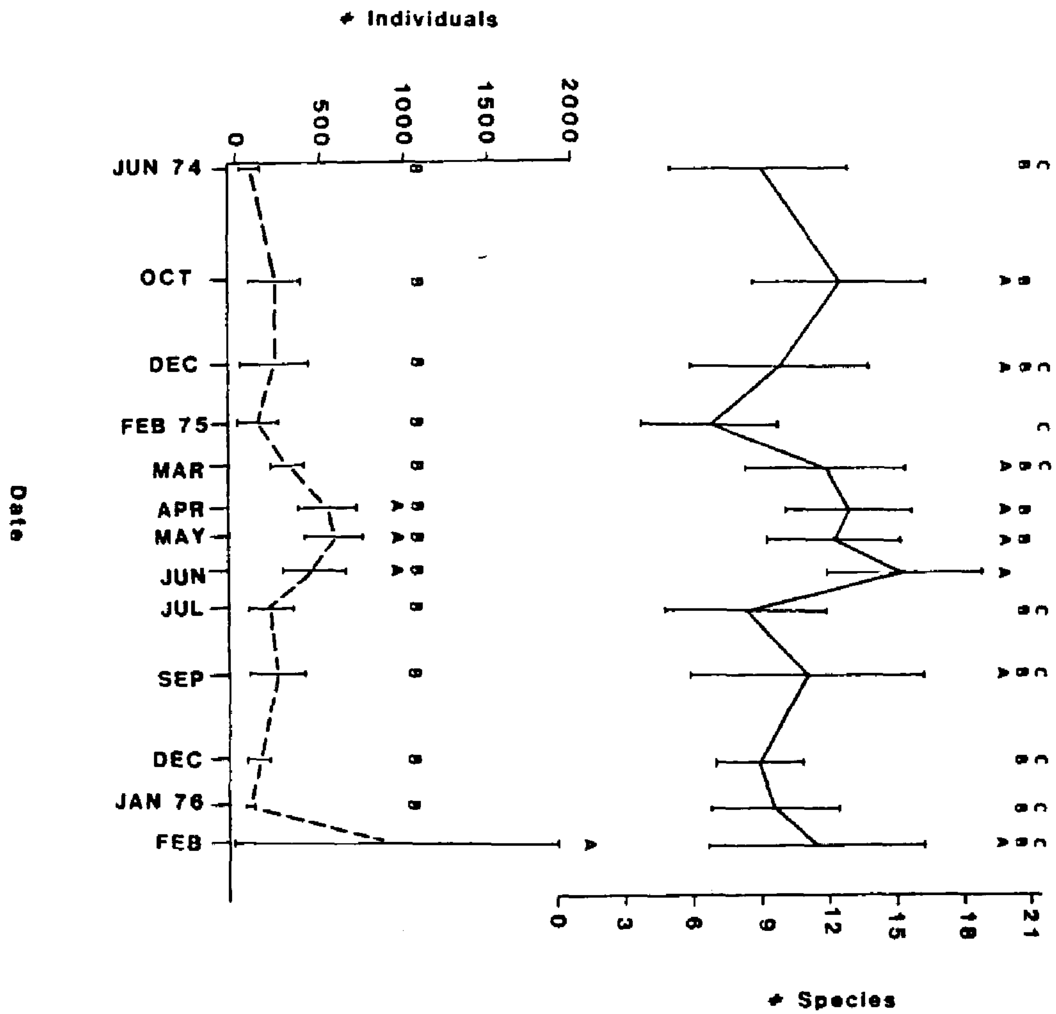
restricted to the more marine stations. Trachypenaeus similis was not collected at stations 1, 3, 5 or 6, and only once when the salinity was less than 17 $^{o}/oo$. Acetes americanus was collected only once when salinity was less than 14 $^{o}/oo$. Xiphopenaeus kroyeri was also restricted to the seaward stations. It was collected at stations 7 and 8 and once each at stations 6 and 10. Salinity was less than 20 $^{o}/oo$ only twice at stations where X. kroyeri was collected. Squilla empusa was collected only at stations 5, 7 and 8 and the salinity was always greater than 16 $^{o}/oo$. Macrobrachium ohione, conversely, was restricted to oligohaline stations. It was not collected at stations 6, 7 or 8 and only once at station 10. Only once was M. ohione collected at a salinity higher that 5.5 $^{o}/oo$.

The invertebrates were also more temporally restricted. Squilla empusa was collected only in October, February and March. Macrobrachium ohione was collected only from March through June and Palaemonetes vulgaris only from February through June. Penaeus aztecus was virtually absent from estuarine waters from September through March, as only six individuals were collected at all stations during those months.

The average number of species collected per trawl sample varied significantly (ANOVA, $P<0.04$) with time (Figure 11). The average number of species per sample was greatest during the summer months and lowest during winter months. The average number of species per trawl sample was significantly greater (Duncan's Multiple Range Test) in July, 1975, than the average number collected in February, September and December, 1975, and January, 1976.

The average number of individuals collected per trawl sample had a

Figure 11. Mean ± S.E. of total individuals (dashed line) and total species (solid line) per trawl by sampling period for all stations. Letters are significant groupings by Duncan's Multiple Range Test.



Individuals
0
500
1000
1500
2000
Date
JUN 74
OCT
DEC
FEB 75
MAR
APR
MAY
JUN
JUL
SEP
DEC
JAN 76
FEB
Species
0
3
6
9
12
15
18
21

pattern similar to the number of species collected and had a highly significant variation with time (ANOVA $P<0.007$) (Figure 11). The average number of individuals per sample in February, 1976, was significantly greater (Duncan's Multiple Range Test) than all sampling times except for the summer months of 1975.

The spatial variation in average numbers of species and numbers of individuals per trawl was not as pronounced as their temporal variation. A highly significant variation with station (ANOVA $P<0.001$) was found in average number of species collected, with station 7 having a significantly higher number of species than all other stations (Figure 12). No significant variation in numbers of individuals by station existed. However, if the stations are arranged with respect to distance from the mouth of the estuary, a trend of greater average numbers of both species and individuals per trawl sample with proximity to the mouth of the estuary exists (Figure 12).

Community Structure

Attributes of community structure, including number of species, number of individuals, diversity (H'), evenness (J') and probability of interspecific encounter (P.I.E.), are listed by station for all sampling periods in Appendices 14-22. All stations had significant within-station variation with time for all attributes. No significant difference existed, however, between the means of the stations attributes grouped by sampling period across time (Figure 13) or for the means of all attributes grouped by sampling period across stations (Figure 14). The mean evenness values for the estuary were lowest during the spring months when trawl samples consisted predominately of

Figure 12. Mean ± S.E. of total individuals (dashed line) and total species (solid line) collected per trawl by station for all sampling periods. Asterisk denotes significant difference by Duncan's Multiple Range Test.

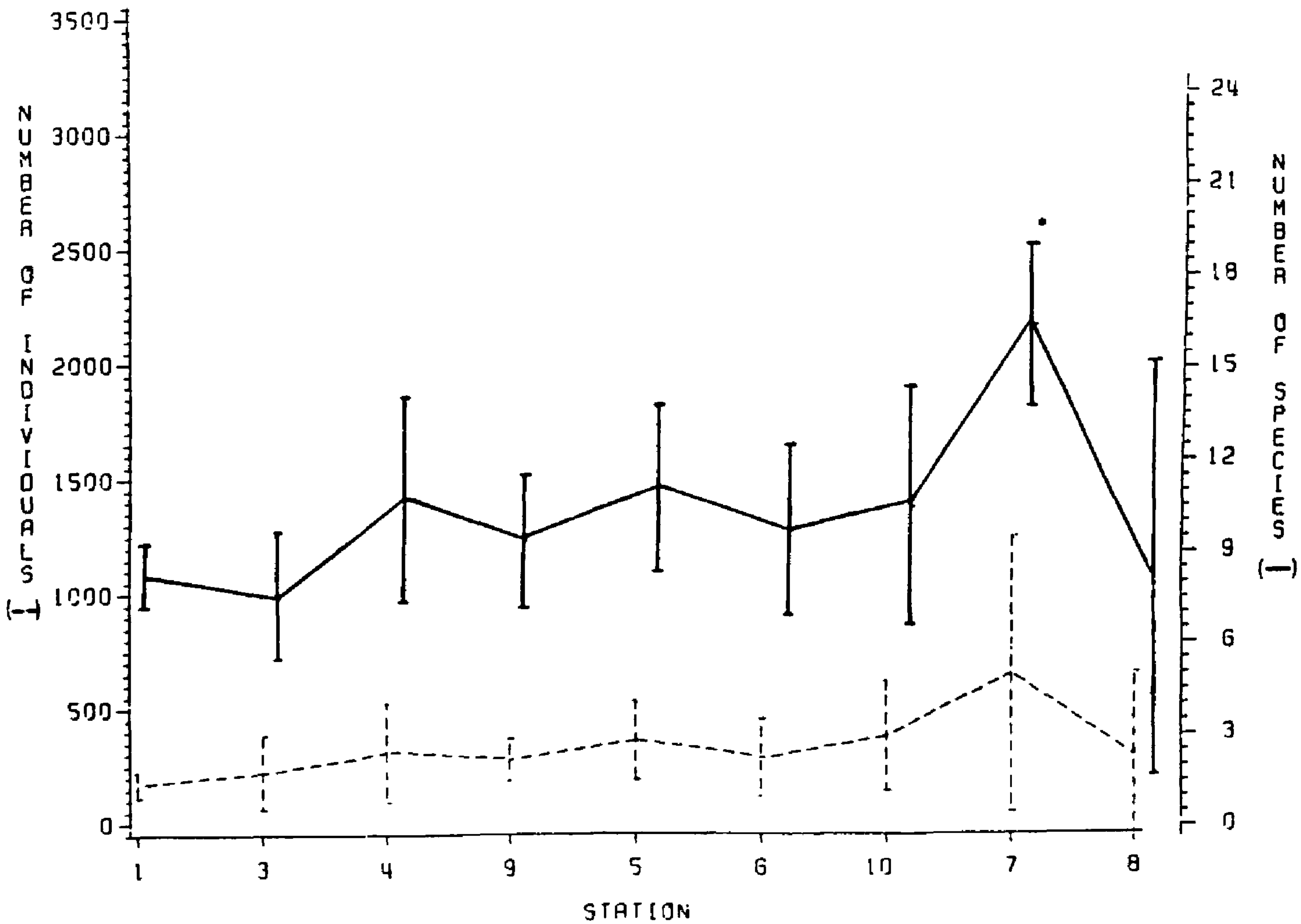
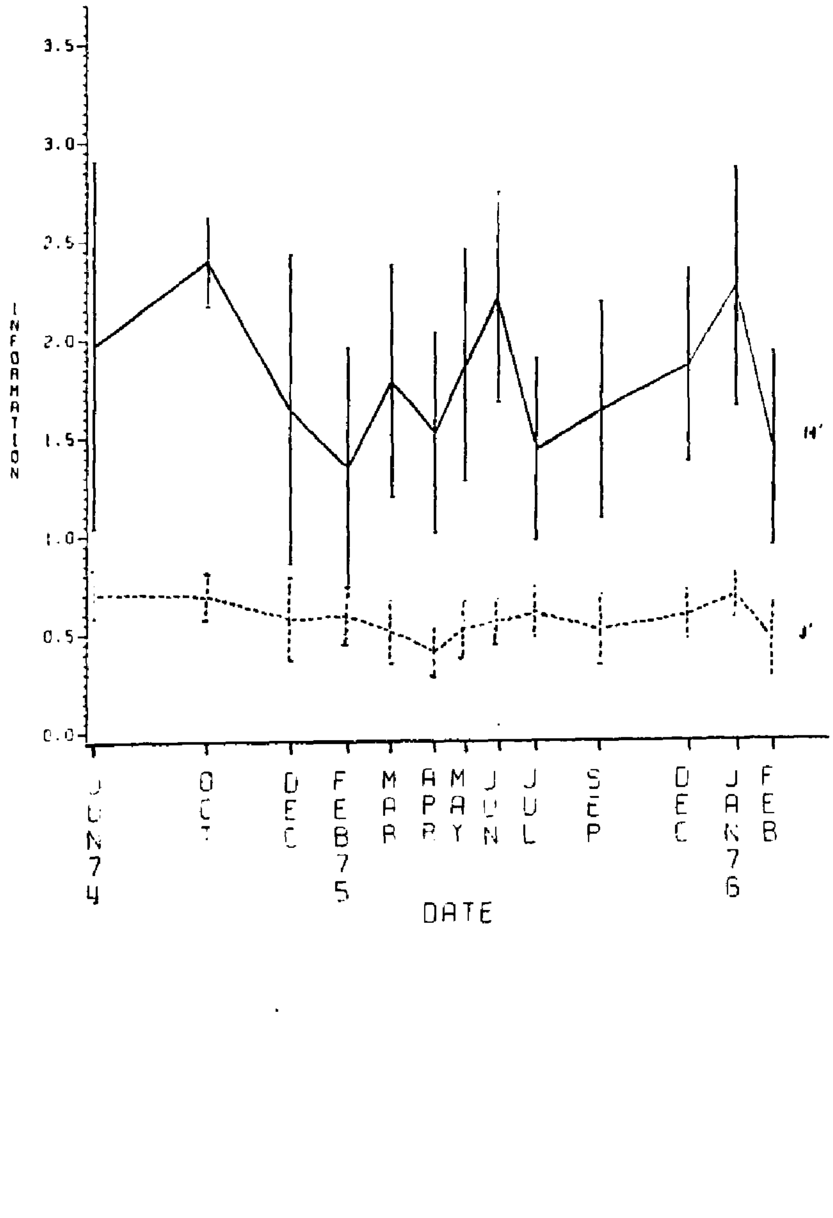
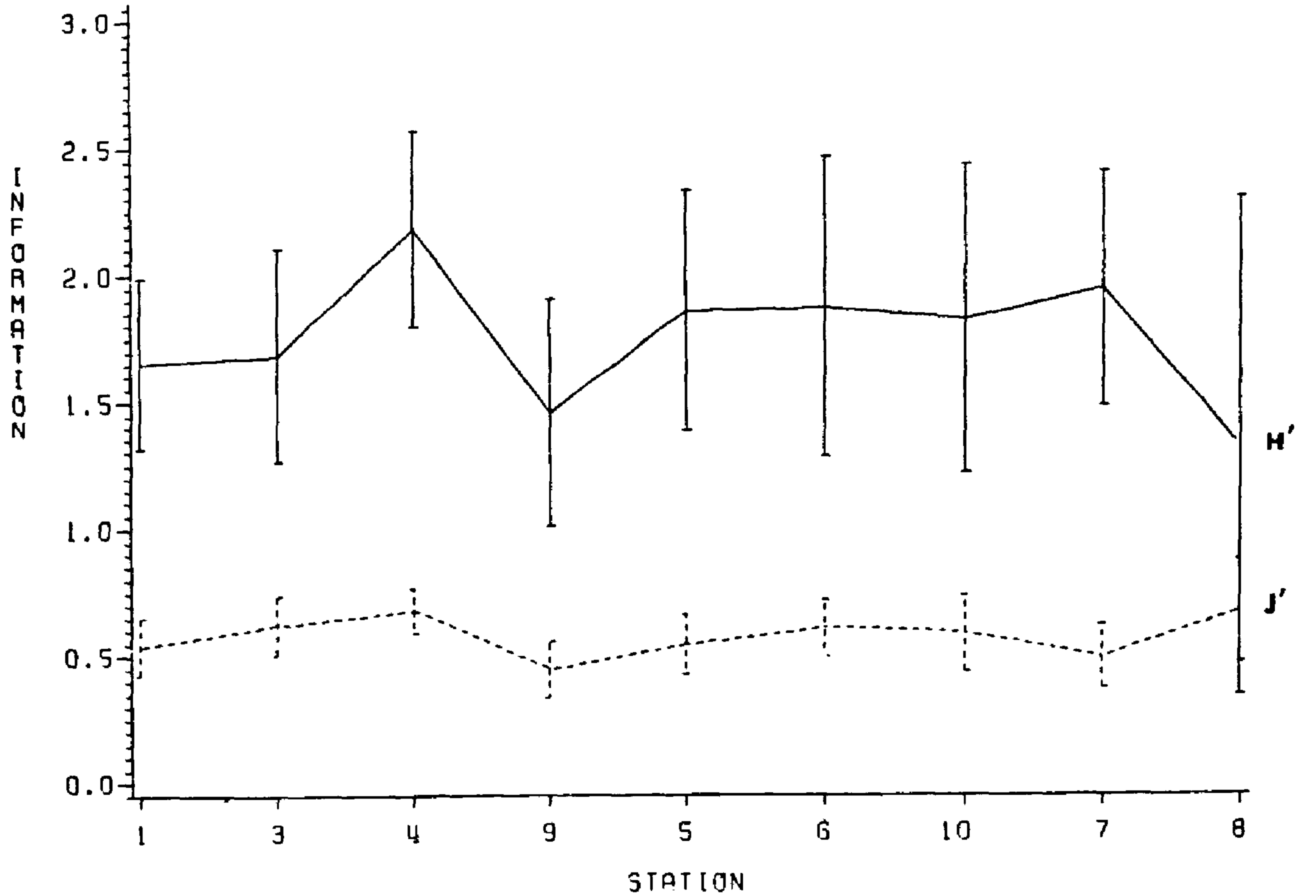

NUMBER OF INDIVIDUALS
NUMBER OF SPECIES
STATION
3500
3000
2500
2000
1500
1000
500
0
24
21
18
15
12
9
6
3
0
1
3
4
9
5
6
10
7
8
*

Figure 13. Mean ± S.E. of H' (solid line) and J' (dashed line) of trawl samples by sampling periods for all stations.



INFORMATION
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
H'
J'
JUN74
OCT
DEC
FEB75
MAR
APR
MAY
JUN
JUL
SEP
DEC
JAN76
FEB
DATE

Figure 14. Mean ± S.E. of H' (solid line) and J' (dashed line) of trawl samples by station for all sampling periods.



INFORMATION
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
3
4
9
5
6
10
7
8
STATION
H'
J'

juveniles of the more abundant species. Mean diversity values were lowest during February of both years, when many species were not present in the estuary and juveniles of a few species were abundant. The low diversity values for July, 1975, and the large standard error for June, 1974, are due to oxygen depletion and a resulting dearth of organisms at station 8. This phenomenon resulted in station 8 having the lowest average diversity of all stations.

Classification

Species which have a low number of occurrences present insufficient information to permit analysis of either their spatial or temporal distribution and consequently are usually of little aid in classifying stations or samples. Only those species which occurred in more than five samples were included in classificatory analysis in the present study. Of the 131 species collected in trawls, 47 were used in classification.

Stations with a small number of species likewise tend to possess insufficient attributes for meaningful classification and often group together. Only samples with more than five of the species used in classification were analyzed. Fifteen of the 100 trawl samples were eliminated.

Normal Analysis (Q or Station)

The 85 trawl samples were clustered with the flexible group sorting strategy into eight heirarchical groupings (Figure 15). The distribution of the trawl samples among the station groups is presented in Figure 16.

Group A contained 15 samples, all of which form a contiguous

Figure 15. Dendrogram of flexible sorting cluster of Canberra metric analysis of stations.

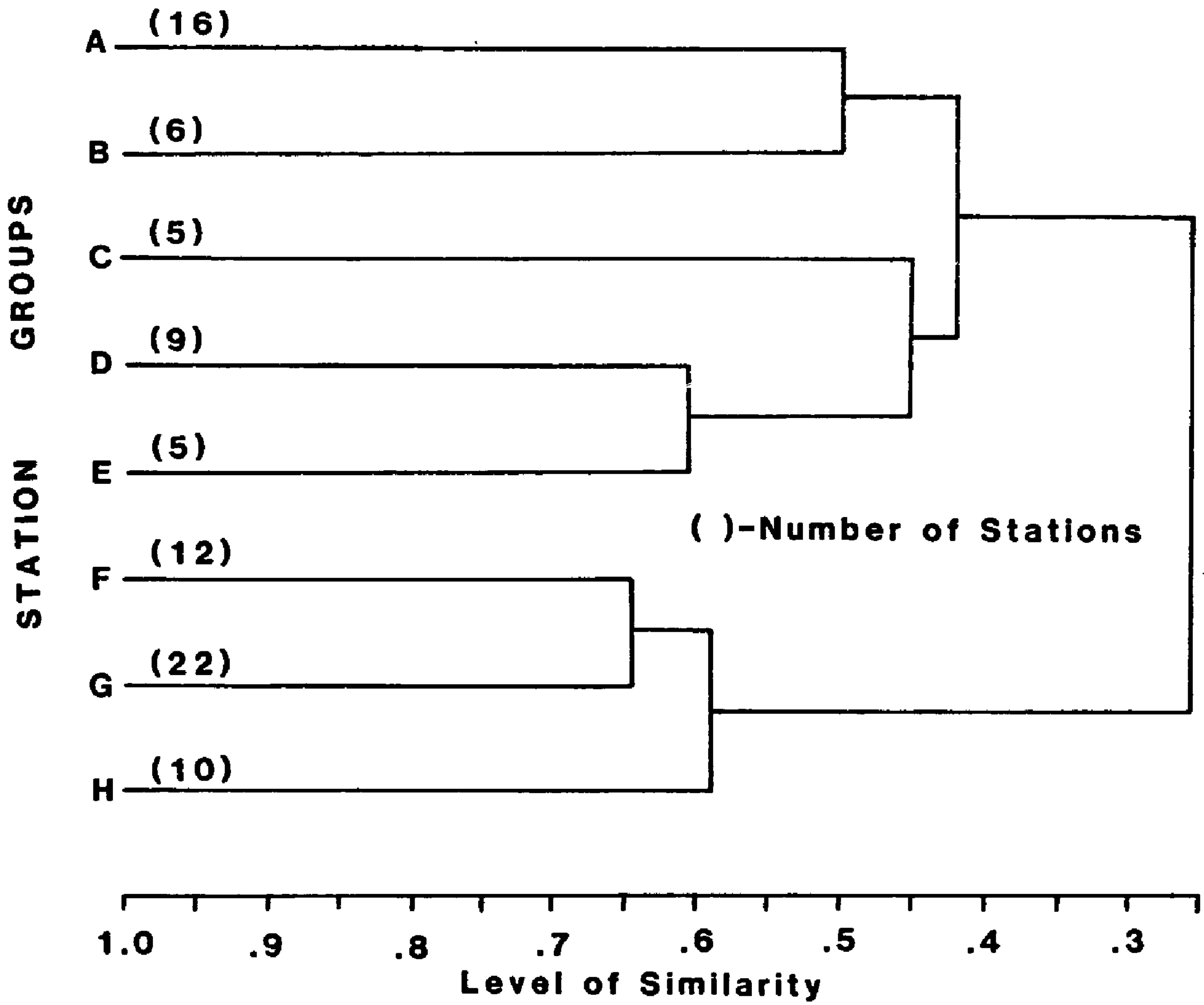

STATION GROUPS
A (16)
B (6)
C (5)
D (9)
E (5)
F (12)
G (22)
H (10)
( )-Number of Stations
1.0
.9
.8
.7
.6
.5
.4
.3
Level of Similarity

Figure 16. Spatial and temporal distribution of station groups A-H. Samples noted by an S had an insufficient number of species to be classified. X denotes no sample taken.

DATE

STATION	74 Jun	Oct	Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	Jan	76 Feb
1	G	F	G	S	G	G	G	G	G	G	G	G	G
3	G	G	H	S	F	A	G	G	S	S	G	H	S
4	S	D	H	H		A	A	A	G			H	G
9			H	F	H	A	A	A	B	G	G	S	F
5	E	E		F	G	A	A	B	B	D	F		G
6	E	D	F	S		A	A	B		D	F	H	
10				F	F	S	A	A	B	D	H	H	A
7	B	D	C	D	D	C	C	B	E	D	F	F	A
8	S			S	C				S	E			C

assemblage distributed from station 3 through 10 during the months of April through June, 1975, with the exception of samples from stations 7 and 10 in February, 1976. The assemblage was characterized not only by its temporal restrictions but also by low mesohaline salinities (Table 5).

Group B is a small assemblage of seven samples all collected from stations 5 through 10 during June, 1974, or during June or July, 1975. The salinity varied from 5.5 to 25 ^{o}/oo.

Group C is another small assemblage of five samples characterized by location, as all were from either station 7 or 8, and had polyhaline salinities.

Group D has 9 samples that were collected from September through February of both years, with the exception of one sample collected in March, 1975. All samples were from stations 4-7 or 10. Four adjacent stations in September, 1975, were classified in D. The salinity of the stations was mesohaline (mean = 17.4 ± 1.9 ^{o}/oo S).

The five samples in Group E were collected in June, July, September or October at stations 5 through 8. The average salinity was 19.1 ± 3.1 ^{o}/oo. Group E had the highest mean diversity and P.I.E. values.

The 12 samples in Group F were collected from October through February, with the exception of two samples collected in March. Salinity ranged from 3.3 to 19.3 ^{o}/oo.

Group G was the largest group, containing 22 samples. The assemblage is very homogeneous with respect to both spatial distribution and salinity. Eleven of the thirteen samples collected from station 1 were classified into Group G. Five samples from station 3 and two each

Table 5. Attributes of station groups. Means are given ± S.E.

Group	N	S(^{o}/oo)	H'	J'	P.I.E.	Temporal Distribution	Spatial Distribution (stations)
A	15	7.0±1.7	2.03±.20	0.517±.048	0.607±.057	Apr-Jun, Feb	*
B	7	11.6±3.1	2.27±.22	.613±.064	.673±.069	Jun-Jul	*
C	5	25.0±3.5	1.79±.24	0.432±.058	0.527±.086	*	7,8
D	9	17.4±1.9	1.71±.24	0.465±.061	0.514±.078	Sep-Feb	4-7, 10
E	5	19.1±3.1	2.80±.24	0.729±.064	0.772±.058	Jun-Oct	5-8
F	12	12.3±2.0	1.71±.20	0.580±.054	0.570±.057	Oct-Feb	*
G	22	5.3±.0.8	1.57±.13	0.500±.045	0.494±.047	*	73% from 1,3
H	10	10.5±1.7	2.56±0.14	0.734±.052	0.747±.051	Dec-Feb	*

* No pattern

from 4, 5 and 9 were assigned to Group G. The salinity was oligohaline (5.3±0.8 ^{o}/oo S). The integrity of the group was confirmed by the uniformity of response of the major subgroups in both nodal constancy and frequency analyses.

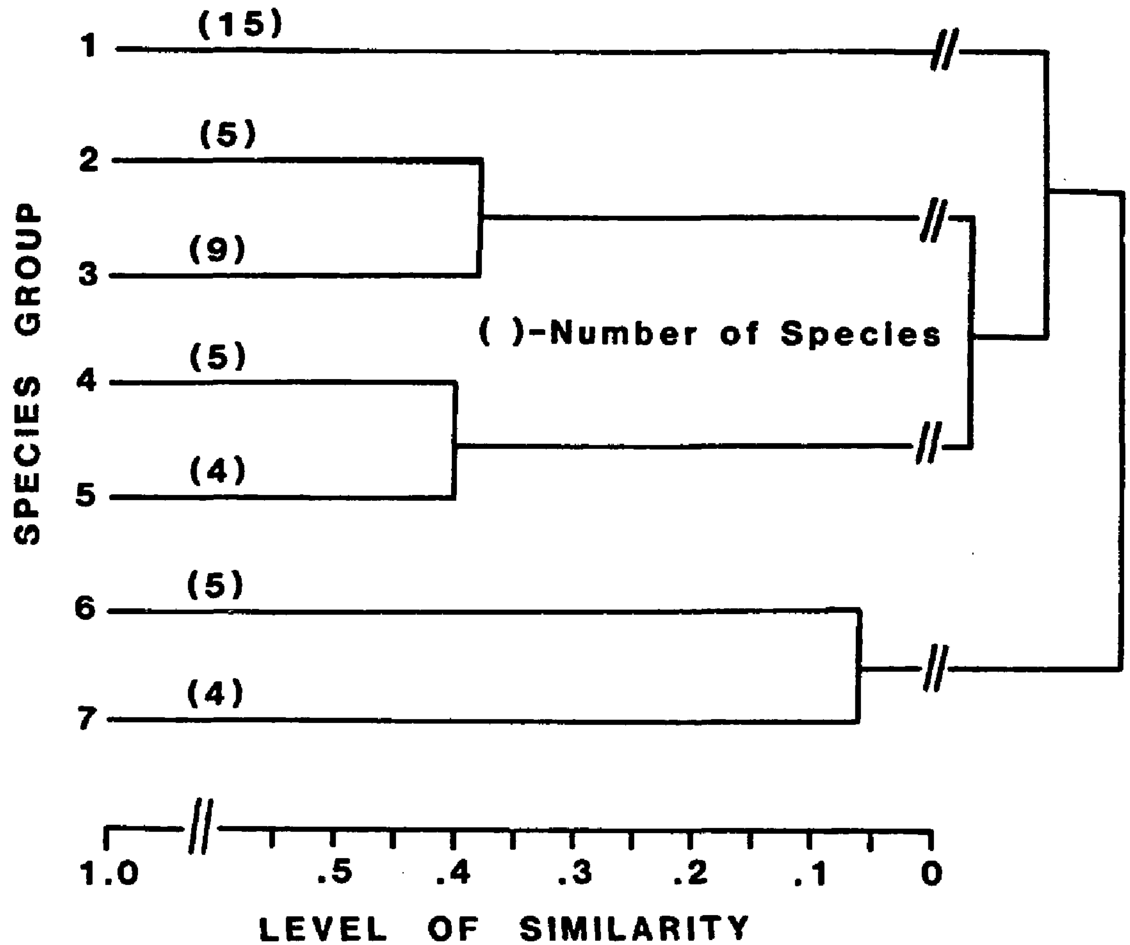
Station Group H is an assemblage of 10 samples that appear to have in common only their temporal occurrence. All samples were collected in December, January or February, with the exception of one sample collected at station 9 in March, 1975. Salinity appears to have little to do with the attributes of the group because salinity varied from 3.2 to 17.4 ^{o}/oo.

Inverse Classification

A fixed truncation level (i.e., a constant level of fusion) was not used to delimit groups. Groups were selected by proceeding in the direction of increasing diffusion in the clusters until cohesive units were subjectively determined to exist. Although differential truncation introduces subjective decisions, deficiencies of the clustering methodology may be countered (Williams *et al.*, 1971). Most clustering strategies are group-size dependent in that as the number of entities (sites or species) in a group increases, the group's affinities to other groups becomes more diffuse (Clifford and Stephenson, 1975). Some groups may be spuriously isolated because of the number of entities they contain.

A simplified dendrogram depicting the seven species groups selected is presented in Figure 17. "Misclassifications" of entities commonly occur in clustering algorithms due to early dichotomies in divisive programs or because fusions begin where group affinities are weakest in

Figure 17. Dendrogram of heirarchical clustering of species groups.


SPECIES GROUP
1
(15)
2
(5)
3
(9)
4
(5)
5
(4)
6
(5)
7
(4)
( )-Number of Species
1.0
.5
.4
.3
.2
.1
0
LEVEL OF SIMILARITY

agglomerative programs (Clifford and Stephenson, 1975; Williams *et al.*, 1971). Misclassifications may be detected by inspection of a two-way coincidence table. The methodology has been referred to as "Zurich-Montpellier" analysis by Popham and Ellis (1971), who used visual inspection of a binary matrix. Normal and inverse analysis are arranged so as to produce a two-way coincidence table having species as columns and site groups as rows. The degree of changes to the fidelity and constancy of a species group by the removal or addition of a species is a measure of the effectiveness of the classification.

The members of each species group are listed in Table 6. Several possible misclassifications were found, but none had sufficient impact to alter the group's ranking within fidelity or constancy classes. The misallocated species were generally characterized by having insufficient frequency or abundance to permit distinctive patterns. *Urophycis floridanus* was apparently misclassified into species group two and was reallocated into group 1.

Group 1 is an assemblage of 15 species that is characterized by a low number of occurrences and individuals. No species occurred in more than 15 samples or was represented by more than 34 individuals. Many of the species are inshore coastal species rather than euryhaline estuarine species. The species group accordingly had a low or very low level of constancy at all station groups except C, where it had a moderate constancy (Figure 18). Station group C contains only samples collected at stations 7 and 8 and had the highest average salinity of all station groups. Species group 1 also had a high fidelity value in group C and low or negative fidelity at all other station groups (Figure 19). The

Table 6. Members of species groups resulting from cluster analysis. Rare = <25 individuals/species; common = 25 - 250 individuals/species; abundant = >250 individuals/species.

SPECIES GROUP 1
(Rare; offshore affinities)

Bagre marina
Clibanarius vittatus
Cynoscion nebulosus
Hexapanopeus paulensis
Lironeca ovalis
Lolliguncula brevis
Menticirrhus americanus
Mugil cephalus
Paralichthys lethostigma
Peprilus burti
Porichthys porosissimus
Rhithropanopeus harrisii
Trichiurus lepturus
Trinectes maculatus
Urophycis floridana

SPECIES GROUP 2
(Common; oligohaline; no temporal affinities)

Dorosoma cepedianum
Dorosoma petenense
Ictalurus furcatus
Macrobrachium ohione
Mytilopsis leucophaeata

SPECIES GROUP 3
(Common; mesohaline; seasonal)

Aegathoa oculata
Archosargus probatocephalus
Callinectes similis
Caranx hippos
Citharichthys spilopterus
Opisthonema oliglinum
Peprilus alepidopus
Pogonias chromis
Symphurus plagiusa

SPECIES GROUP 4
(Common; mesohaline; seaward stations)

Chaetodipterus faber
Chloroscombrus chrysurus
Larimus fasciatus
Palaemonetes vulgaris
Polydactylus octonemus

SPECIES GROUP 5
(Abundant; polyhaline)

Acetes americanus
Stellifer lanceolatus
Trachypenaeus similis
Xiphopenaeus kroyeri

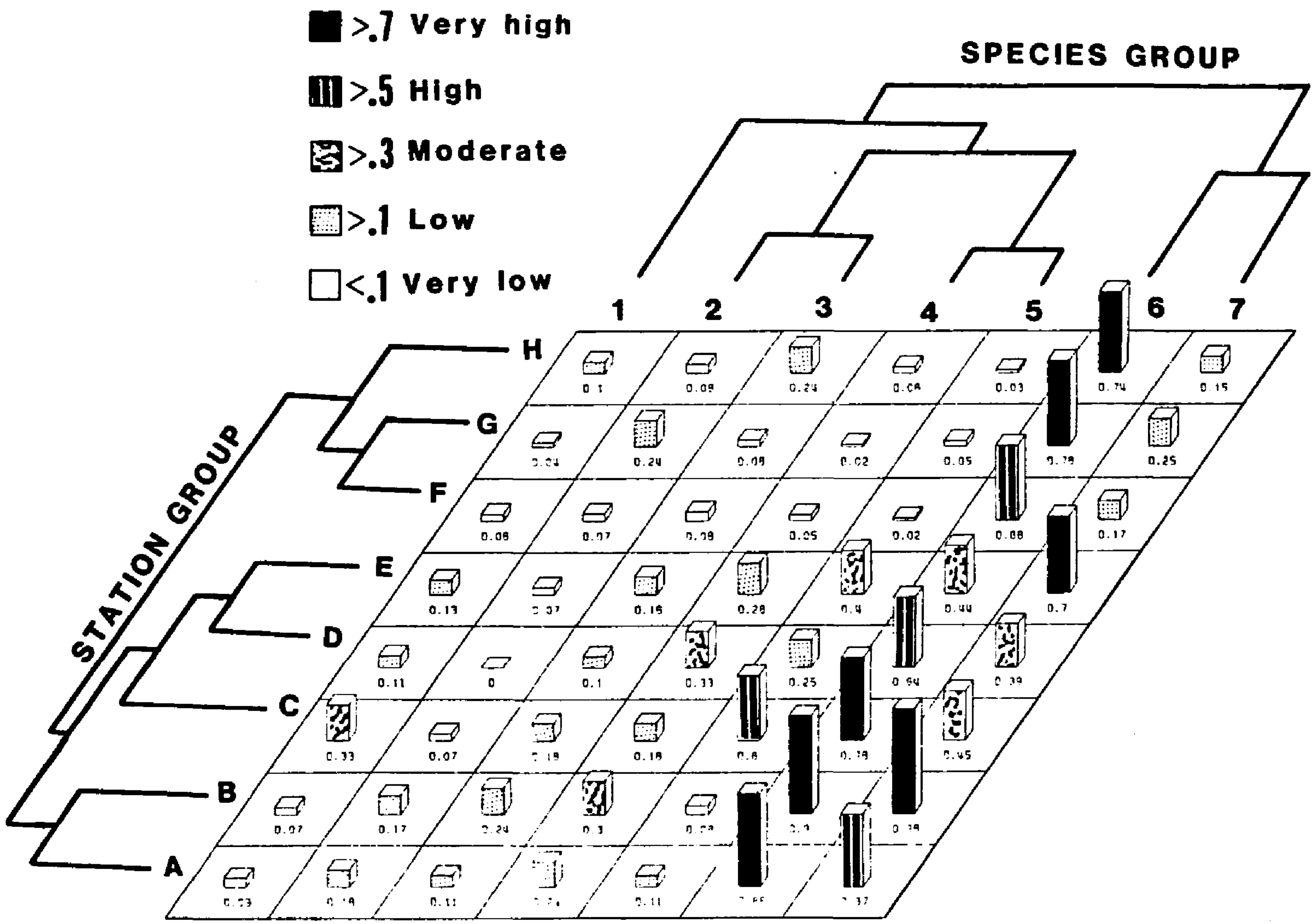
SPECIES GROUP 6
(Abundant; ubiquitous)

Anchoa mitchilli
Callinectes sapidus
Leiostomus xanthurus
Micropogonias undulatus
Penaeus setiferus

SPECIES GROUP 7
(Abundant; euryhaline; seasonally restricted)

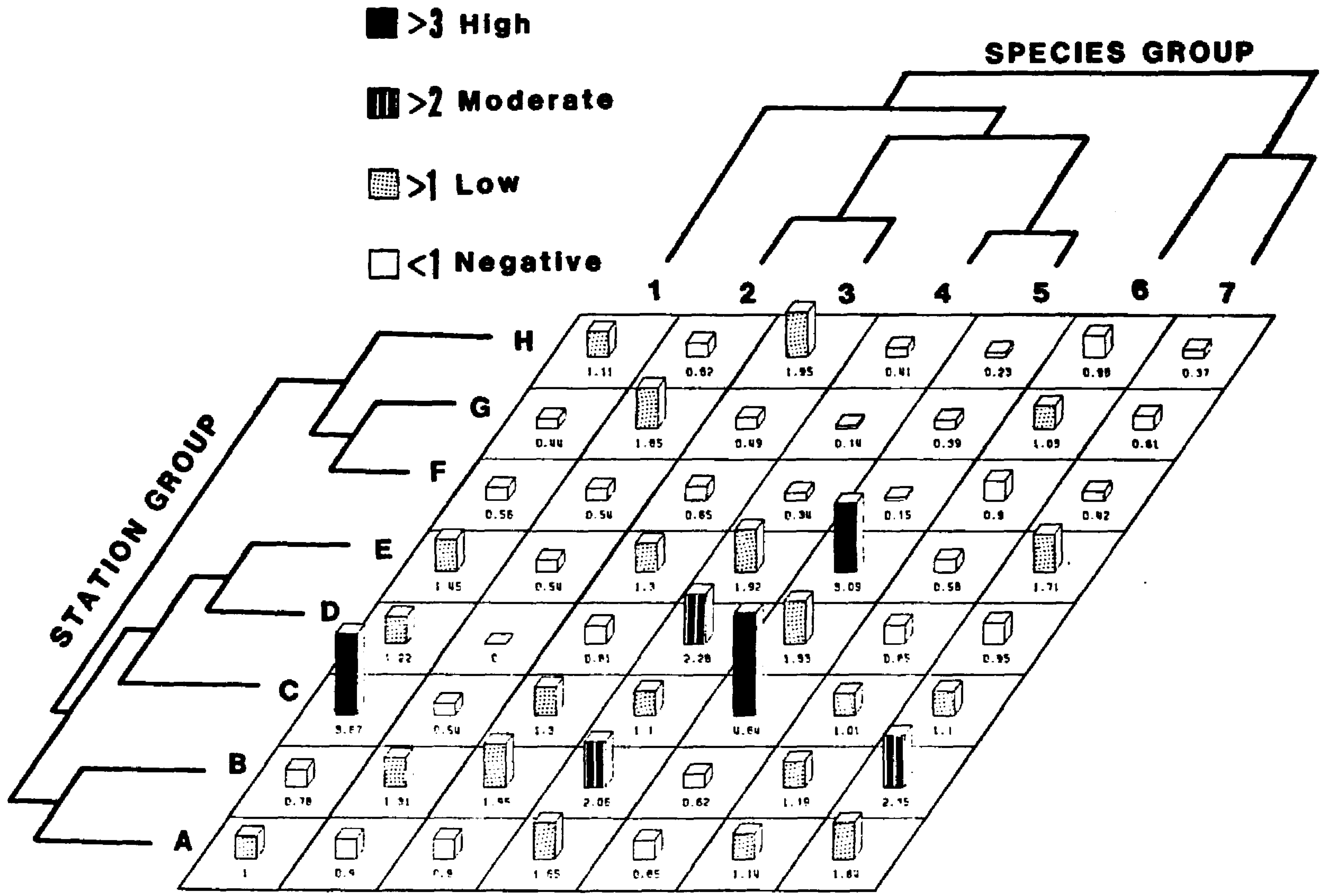
Arius felis
Brevoortia patronus
Cynoscion arenarius
Penaeus aztecus

Figure 18. Nodal analysis of constancy of species groups within station groups.



>.7 Very high
>.5 High
>.3 Moderate
>.1 Low
<.1 Very low
SPECIES GROUP
1
2
3
4
5
6
7
STATION GROUP
H
G
F
E
D
C
B
A

Figure 19. Nodal analysis of fidelity of species groups within station groups.



>3 High
>2 Moderate
>1 Low
<1 Negative
SPECIES GROUP
1
2
3
4
5
6
7
STATION GROUP
H
G
F
E
D
C
B
A

lowest constancy and fidelity values were in group G, the predominately oligohaline samples.

Species group 2 consisted of brackish or fresh water species. Although all species were well represented, the group had low constancy and low or negative fidelity at all site groups. The highest values of both constancy and fidelity were present in the most riverine site groups of the estuary, group G.

The ecological affinities of the species within groups 3 and 4 were not apparent. Both groups were comprised of common species found primarily in mesohaline waters, although the members of group 4 were four times more abundant than those of group 3. The nine species comprising species group 3 were not common in nor restricted to any station group. Their highest constancy and fidelity values, although low, were in station groups H and B, both of which were mesohaline sample groups with different seasonal coverages (Figures 18 and 19). Station group H was restricted to the months of December to February, while station group B was restricted to June and July (Figure 16). Species group 4 had moderate constancy and fidelity at station groups D and B and very low constancy and negative fidelity at station groups F, G and H.

Species group 5 was a group of four species that was abundant in polyhaline waters, having moderate and high constancy at station groups E and C, respectively, with low or very low constancy in all other station groups. The group also had high fidelity in station groups E and C and low or negative fidelity in all other station groups.

Species group 6 is an assemblage containing the numerically dominant, true euryhaline species, having very high constancy in five of the eight station groups and moderate or high constancy in the other station groups. The ubiquity of the species members is demonstrated by their low to negative fidelity in all station groups.

Species group 7 also contains four of the most numerically abundant species, but all of the species are temporally restricted. Consequently, the group has very high constancy only in station groups B and E, both of which only contain samples from June through October. The group has its lowest constancy value in station group F, which contains samples from October through February. The spatial ubiquity of the species group is demonstrated by its having only a moderate fidelity in a single station group, with low or negative values in all other groups.

DISCUSSION

The seasonal variation in number of species and number of individuals in the estuary were similar (Figure 11). The number of species present during the spring and early summer months was significantly greater than the number present during late summer and winter months. An increase in the number of individuals occurred during the spring and early summer months due to the recruitment of juveniles. Similar seasonal patterns of abundance and species richness have been reported for the demersal nekton of other estuaries (McErlean et al., 1973; Wagner, 1973), but Livingston (1976) found seasonal peaks of numbers of species, numbers of individuals and species diversity occurred in the summer and fall for the demersal fishes and invertebrates of a north Florida estuary.

When the number of species and the number of individuals of each species were considered interactively, with stations pooled, as in Shannon's diversity index, evenness and P.I.E., the pattern of seasonal variation was not evident (Figure 13). The summarization of community structure as a single index by necessity requires a reduction in information. Assemblages containing different kinds and numbers of species and individuals can have the same diversity, as species identities are lost.

The relative seasonal stability of the community structure of the Calcasieu estuary, as depicted by diversity indices summed across stations, belies the dynamic nature of the population fluctuations of the component species. Intrastation seasonal variation was large for all stations. Strong seasonal fluctuations in the species composition occurred, with specific dominants moving in and out of the estuary at various seasons.

The basic premise of the diversity-stability hypothesis was the principle that increased species diversity was synonomous with greater stability (MacArthur, 1955). Biological systems with higher species diversity, and the resulting increased complexity of energetic pathways, were reasoned to have greater resilience and be less subject to alteration by perturbation due to the greater number of alternatives for energy flow and biotic interactions.

The use of indices of diversity as a biological criterion of environmental quality were introduced by Wilhm and Dorris (1966, 1968) in work with freshwater benthos. They suggested that severely polluted areas had low diversity (<1.0) while unpolluted areas had higher diversity (>3.0) and that species diversity indices could be used for establishment of water quality criteria. The species diversity and related attributes of community structure of the benthos from widely disparate locations and habitats were compared in the ensuing literature and related to differences in sedimentology, hydrography, environmental stability, or more commonly, anthropogenic modifications. Diverstiy indices of nektonic assemblages were subsequently reported to be also inversely related to pollution (Betchel and Copeland, 1970) and were used in developing predictive models (Copeland and Betchel, 1971; McErlean _et al._, 1973).

The biological interpretation of information theory and the theoretical tenets of the diversity-stability hypotheses have been questioned (Hurlburt, 1971; Boesch and Rosenberg, 1981; Goodman, 1975; Abele and Walters, 1979). Stability and resilience are apparently not related to diversity in many systems and may even be inversely related to diversity in others (Copeland, 1970). Seasonal fluctuations of diversity in estuarine nektonic assemblages are well documented (McErlean _et al._, 1973; Livingston, 1976; Pimm, 1979, 1980) and have serious implications for their use in assessment of estuarine environmental quality. The ability to differentiate the effects of anthropogenic perturbations from natural stresses against a background of seasonal variation is exceedingly difficult (Mauer _et al._, 1979).

Despite the questionable efficacy of diversity indices, in many instances they were useful as data reduction aids in evaluating community structure. When diversity indices are evaluated in the context of the variation present between and within habitats, and with knowledge of the diversity of parallel "non-polluted" systems, they may be sensitive to even moderate degrees of pollution (Boesch, 1972).

Seasonal differences in diversity indices were evident in the present study within stations, but a well developed cycle was not discernable within any station. Dahlberg and Odum (1970) likewise did not find a well defined cycle over a one year study in a Georgia marsh nor did Quinn (1980) in the fish assemblages of an Australian estuary, although individual populations cycled with abiotic variation. The lack of utility of diversity indices in assessing seasonal dynamics of fish populations in an estuary in the southern Gulf of Mexico was reported by Yanez et al., (1980) to be due to species replacement. McErlean et al. (1973) found strong seasonal cycles in Shannon's index (H') and less defined cycles in evenness (J') in the fish populations of the Patuxent estuary, Maryland, during a four year study. Distinct seasonal fluctuations in diversity values were reported for an unpolluted estuary on the Gulf coast of Florida, but annual variations in the peak occurrences were noted, with little uniformity among the individual stations (Livingston, 1976). Distinct seasonal trends in diversity indices of fish species were found in a two year study in Galveston Bay, Texas (Gallaway and Strawn, 1975).

The lack of parallel non-polluted stations (Boesch, 1972) hindered assessment of environmental quality within the Calcasieu estuary by means of diversity values, but the indices were useful however, in affirming the relation- ships between clusters of station groups. Station groups within clusters had similar diversity, evenness and

P.I.E. values, except for station groups D and E, which were considerably different in all attributes (Table 5).

All of the indices had similar trends, whether grouped by sampling station or assemblage group. No relationship was found between the indices and salinity, either within a single station over time or within station groups. Despite Hurlburt's (1971) criticism of the heuristic nature of indices based on information theory, his probability of intraspecific encounter (P.I.E.) had the same trends as H' and was of no more interpretive value.

Analysis by numerical classification (classification and cluster analyses) was more informative of the spatial and temporal changes in community structure occurring in the Calcasieu estuary. The temporal restriction of some species groups was demonstrated by their high degrees of fidelity (Figure 19) in station groups that were temporally restricted (Figure 16). Most of the station groups had discernable temporal attributes: Group A was primarily composed of samples collected in June or July, Group D consisted of samples from September to February, Group E consisted of samples from June to October and Group F was composed of samples collected from October to February (Figure 16, Table 5).

Biotic interactions within the estuary were implied not only by the temporal partitioning, but also by apparent spatial partitioning. The ten most abundant fish and invertebrate species (Table 4) are distributed among five different species groups (Table 6). All congeneric pairs are separated into different species groups except for *Dorosoma cepedianum* and *D. petenense*. Even the *Dorosoma* spp.

co-occurred only in four of the 24 samples in which they were collected. Closely related species also tended to have more widely spaced centers of distribution, e.g. *Arius felis*, *Bagre marinus* and *Ictalurus furcatus* were each in different species groups, as were *Macrobrachium ohione* and *Palaemonetes vulgaris*. *Ictalurus furcatus*, the Blue Catfish, Family Siluridae, appeared to be the oligohaline ecological equivalent of the Sea Catfish, *Arius felis*, even though the latter is in a different family (Ariidae). *Ictalurus furcatus* was classified in species group 2, which had its highest constancy and fidelity (both low) in station group G, which had the lowest average salinity of any station assemblage. The Sea Catfish, which had a similar morphology and is also a bottom feeder, was classified in species group 7, which had a very high constancy in both station groups B and E and high constancy in group A. Species group 7 had its highest fidelity in station group B, which had an average salinity of 11.6 $^{o}/oo$. The centers of distribution for the two species would probably have been more widely separated if a station more up-estuary had been sampled.

Only two of the species groups (6 and 7) have high constancy in more than two station groups (Figure 18) and only a single station group, C, has more than a single species group with high fidelity. The heterogeneity of species group fidelity and the low incidences of high constancy are both indicative of complex patterns of utilization of the estuary.

The defaunation caused by hypoxic bottom waters (< 2 ppm dissolved O_2) found in this study is apparently a common phenomenon off the Louisiana coast (Bedinger, 1981; Harper *et al.*, 1981). The combination of water column stratification and calm weather inhibit vertical mixing and cause oxygen depletion, particularly during warm months when biological and chemical oxygen demands are high. The collection of only two *Callinectes sapidus* at station 8 in June, 1974, may have been related to a recent period of hypoxia, even though the D.O. at the time of sampling was 3.62 ppm. An area of approximately 50 km in diameter, principally within the 50 m isobath of the western Louisiana coast, was devoid of demersal nekton two weeks prior to the Calcasieu sampling. Repeated trawling by the NMFS R/V OREGON II found only isolated Cow-nosed Rays (*Rhinoptera bonasus*) to be alive in the area (unpublished personal observations). Cow-nosed Rays feed principally on infaunal bivalves (Orth, 1975) and infaunal bivalve populations were among the few invertebrate taxa reported by Harper *et al*. (1981) to be unaffected by hypoxic conditions in a three year study on the Texas coast. The Sea Catfish, *Arius felis*, the only species collected at station 8 during hypoxic conditions in July, 1975, is one of the few nektonic species found in hypoxic zones off the Lousisana coast (Fotheringham and Weissberg, 1979).

A soft-bottom community in Tampa Bay that is subjected to total defaunation annually due to anoxic and hypoxic conditions was found to be stable over time in that it regularly returned to its state prior to defaunation (Santos and Bloom, 1980). When resiliency is viewed as the most critical aspect of stability, the nektonic communities, by virtue of their greater motility, and therefore faster response time, might be considered very stable with respect to such perturbations.

Although hypoxia was recorded in June, 1974, and May and July, 1975, the phenomenon was not restricted to warmer months. In both February of 1975 and 1976, hypoxic conditions were also recorded at all channel bottom stations. The impact of the hypoxic conditions on the biota was perhaps less evident because of lower water temperatures and the resulting lower oxygen demand by organisms, and because of the smaller number of species and individuals present. The causative agents of hypoxic conditions in February are probably similar to those in warmer months. A well marked halocline was present at channel stations and the offshore station in both years, although no thermocline was observed. The chlorophyll A concentrations at the same stations were among the lowest recorded during the study (Denoux, 1976). The stratification of water masses, lack of mixing, and a small complement of oxygen producing phytoplankters probably resulted in the hypoxia.

In February, 1975, heteronereid *Neanthes succinea* were observed swarming and large numbers were collected in surface plankton tows (Denoux, 1976). In January, 1976, the same phenomenon was observed in late January and numbers were collected in trawl samples. Swarming of *N. succinea* in early February, 1973, and late January, 1974, were reported for other areas of the Louisiana coast (Bishop, 1974; personal observation). Hypoxia has been implicated as a physiological trigger for hatching in numerous taxa (Petranka *et al.*, 1982) and with mass migrations of demersal fish and crustaceans into shallow water (Loesch, 1960; May, 1973) and it is interesting that the swarming of nereid polychaetes was concurrent with hypoxic conditions in this study.

Although the life history and demography of the major estuarine epifaunal organisms in the Gulf of Mexico have been well studied (see

Gunter, 1967, or Hoese and Moore, 1977, for review), few investigations have focused on the community structure or characteristics of the assemblages resulting from the component species. Numerical classification was used in the present study to allocate trawl samples into eight groups which had as their major attributes either: a) temporal restriction, or seasonal occurrence, b) habitat restriction, or site groups characterized by occurrence at particular habitats, and c) site groups that were characterized by an interaction of seasonal and habitat restriction. Inverse classification allocated the species into seven species groups, which via nodal analysis could be assigned resident, seasonal, habitat-restricted and seasonal habitat-restricted status.

Temporal changes in both abundance and composition were the primary characteristics of the demersal macrofauna of the Calcasieu estuary. Most of the species collected, with the exception of a few euryhaline residents, exhibited seasonality in either their frequency of occurrence or abundance. Data reduction techniques such as numerical classification that are information conserving are a requisite for recognizing complex faunal patterns for use in predictive models in estuarine management.

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Appendix 1. Water physicochemical parameters at station 1.

Surface

Month	Ca (‰)	Mg (‰)	Na (‰)	K (‰)	Cl (‰)	Sal. (‰)	Cond. (mmho)	Temp. (°C)
1974 June	0.041	0.123	0.609	0.037	1.11	2.3	4.1	27.2
October	0.077	0.278	1.750	0.039	3.16	4.8	8.0	23.9
December	0.018	0.058	0.362	0.016	0.23	1.4	1.8	11.5
1975 February	0.015	0.024	0.184	0.011	0.40	0.8	1.1	16.2
March	0.034	0.064	0.506	0.029	2.17	3.0	-	16.9
April	0.007	0.010	0.081	0.005	0.05	1.5	0.6	22.5
May	--	0.001	0.009	0.015	0.02	2.0	0.1	25.8
June	--	0.002	0.014	0.002	0.06	5.5	1.5	29.9
July	0.011	0.042	0.331	0.018	0.94	2.0	3.4	29.5
September	0.009	0.015	0.110	0.009	0.60	1.1	2.0	28.6
December	0.016	0.034	0.271	0.025	1.53	2.9	4.0	15.0
1976 January	0.033	0.119	0.821	0.043	2.48	4.5	5.7	11.4
February	0.015	0.041	0.315	0.187	1.28	2.3	3.6	18.7

Bottom

Month	Ca (‰)	Mg (‰)	Na (‰)	K (‰)	Cl (‰)	Sal. (‰)	Cond. (mmho)	Temp. (°C)
1974 June	0.035	0.100	0.574	0.027	0.94	2.7	4.5	27.3
October	0.096	0.295	1.980	0.133	3.81	5.2	8.4	24.1
December	0.037	0.080	0.299	0.016	1.00	13.9	19.9	18.8
1975 February	0.010	0.027	0.207	0.011	0.43	1.0	1.3	14.7
March	0.035	0.084	0.656	0.034	1.39	3.5	--	16.9
April	0.006	0.011	0.086	0.005	0.07	2.0	0.7	20.9
May	--	0.001	0.009	0.015	0.02	2.5	0.1	25.4
June	--	0.001	0.017	0.002	0.06	2.0	1.8	29.8
July	0.010	0.032	0.024	0.016	1.00	2.1	3.7	28.9
September	0.009	0.023	0.175	0.011	0.72	1.7	3.0	28.6
December	0.024	0.051	0.420	0.030	1.54	3.0	4.2	16.5
1976 January	0.063	0.176	1.242	0.068	3.51	4.4	6.0	12.9
February	0.013	0.033	0.253	0.184	1.28	2.3	3.6	18.6

Appendix 2. Water physicochemical parameters at station 2.

Surface

Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974 June	0.044	0.100	0.747	0.033	1.17	4.7	8.2	27.1
October	0.106	0.300	2.070	0.078	3.45	8.5	14.2	25.8
December	0.030	0.078	0.460	0.023	0.87	2.2	2.7	12.1

Bottom

Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974 June	0.176	0.760	4.920	0.242	8.92	20.0	33.5	28.7
October	0.198	0.780	4.190	0.242	9.90	18.5	--	24.8
December	0.216	0.810	5.200	0.282	9.30	24.5	--	13.4

Appendix 3. Water physicochemical parameters at station 3.

Surface

	Month	Ca (‰)	Mg (‰)	Na (‰)	K (‰)	Cl (‰)	Sal. (‰)	Cond. (mmho)	Temp. (°C)
1974	June	0.090	0.190	1.220	0.063	2.29	7.7	13.9	30.5
	October	0.077	0.480	3.430	0.125	5.17	11.0	18.2	26.2
	December	0.049	0.148	0.816	0.039	1.64	3.2	4.2	13.1
1975	February	0.044	0.099	0.886	0.041	1.66	3.1	4.4	16.4
	March	0.085	0.153	1.150	0.070	2.78	6.0	-	18.6
	April	0.027	0.038	0.329	0.016	0.72	2.5	2.6	23.0
	May	0.008	0.005	0.052	0.004	0.25	1.5	0.9	26.4
	June	0.008	0.004	0.058	0.003	0.24	0.5	0.7	29.8
	July	0.035	0.086	0.069	0.038	2.14	4.1	7.9	32.7
	September	0.031	0.079	0.638	0.035	2.15	4.2	7.6	29.0
	December	0.043	0.143	1.121	0.065	4.48	7.4	10.8	18.0
1976	January	0.068	0.216	1.784	0.082	5.62	9.1	12.2	12.8
	Febraury	0.043	0.194	1.311	0.067	4.47	7.8	11.7	19.8

Apron Bottom

	Month	Ca (‰)	Mg (‰)	Na (‰)	K (‰)	Cl (‰)	Sal. (‰)	Cond. (mmho)	Temp. (°C)
1974	October	0.021	0.021	0.080	0.109	0.19	9.7	16.2	25.8
	December	--	--	--	--	--	3.2	4.2	14.1
1975	February	--	--	--	--	--	3.3	4.5	15.5
	April	0.026	0.038	0.328	0.015	0.82	3.0	2.6	22.6
	May	0.008	0.004	0.052	0.004	0.23	2.0	0.9	26.2
	September	0.043	0.107	0.811	0.048	2.42	4.6	8.1	29.6
	December	0.046	0.130	1.018	0.060	4.69	8.0	11.3	16.4
1976	January	0.057	0.205	1.604	0.079	5.58	9.8	12.8	12.3
	February	0.051	0.165	1.128	0.061	4.45	7.6	11.5	20.4

Appendix 3. Water physicochemical parameters at station 3 (continued).

Channel Bottom

1974	June	0.216	0.760	4.370	0.282	8.95	20.1	34.1	29.6
	October	0.280	0.920	5.380	0.274	10.61	22.0	--	24.8
	December	0.176	0.710	4.650	0.258	8.37	25.0	--	--
1975	February	0.205	0.730	5.658	0.223	10.22	20.0	--	--
	March	0.208	0.875	6.624	0.266	10.78	20.0	--	--
	April	0.358	0.094	0.690	0.046	1.63	5.5	5.9	20.6
	May	0.233	0.653	--	0.251	15.40	28.5	36.8	24.8
	June	0.011	0.021	0.167	0.012	0.74	2.5	3.4	28.7
	July	0.135	0.427	3.140	0.146	10.25	19.0	23.5	29.8
	September	0.127	0.354	2.588	0.136	10.70	19.5	28.0	27.2
	December	--	0.499	3.692	0.180	12.92	26.0	32.2	21.9
1976	February	0.075	0.310	2.149	0.113	9.18	16.5	30.1	15.2

Appendix 4. Water physicochemical parameters at station 4.

Surface

	Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974	June	0.176	0.370	2.300	0.125	4.44	12.4	21.3	28.6
	October	0.156	0.520	4.460	0.172	7.59	12.6	20.5	25.8
	December	0.033	0.088	0.575	0.025	1.01	2.0	2.7	12.4
1975	February	0.0314	0.048	0.414	0.023	0.97	2.2	2.9	13.4
	April	0.0388	0.071	0.840	0.039	1.68	4.5	5.2	23.6
	May	0.005	0.012	0.161	0.006	0.33	1.5	1.3	26.4
	June	0.020	0.036	0.298	0.025	1.27	2.4	4.3	29.5
	July	0.031	0.108	0.880	0.045	2.91	5.3	10.6	32.2
1976	January	0.069	0.229	1.846	0.108	8.29	14.1	17.3	11.7
	February	0.043	0.179	1.180	0.062	4.41	7.7	11.6	20.4

Apron Bottom

	Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974	June	0.244	0.670	4.210	0.219	9.15	13.1	22.5	28.4
	October	--	--	--	--	--	14.2	22.8	25.6
	December	--	--	--	--	--	2.9	3.9	12.8
1975	February	0.063	0.116	0.886	0.053	2.32	4.5	6.1	14.1
	April	0.048	0.113	0.863	0.048	1.99	5.5	6.1	23.4
	May	0.008	0.008	0.074	0.005	0.34	2.0	1.3	26.2
	June	0.016	0.035	0.288	0.021	1.24	2.4	4.4	29.2
1976	February	0.041	0.124	0.849	0.058	4.39	7.8	11.6	20.3

Channel Bottom

	Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974	October	0.308	0.910	5.680	0.344	11.83	24.5	--	--
	December	0.236	0.830	5.200	0.282	10.81	22.5	--	13.5
1975	February	0.225	0.865	6.670	0.285	14.33	23.5	--	--
	April	0.045	0.109	0.828	0.057	2.24	5.5	6.8	21.9
	May	0.192	0.572	4.589	0.254	15.67	29.0	36.8	24.9
	June	0.055	0.147	1.173	0.065	4.04	9.0	12.8	28.6
	July	0.138	0.446	3.215	0.185	11.06	20.0	28.5	29.8
1976	January	0.117	0.421	2.967	0.149	--	20.5	17.2	16.4
	February	0.084	0.363	2.398	0.111	8.38	15.0	17.9	16.4

Appendix 5. Water physicochemical parameters at station 5.

Surface

	Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974	June	0.144	0.410	3.520	0.141	5.26	15.1	24.5	26.1
	October	0.198	0.540	2.690	0.188	7.37	15.2	23.8	24.1
1975	February	0.080	0.248	1.886	0.010	3.65	6.9	9.3	13.7
	March	0.095	0.360	2.760	0.147	6.46	10.5	14.3	15.8
	April	0.056	0.086	0.713	0.035	1.66	4.3	5.4	22.8
	May	0.010	0.017	0.129	0.008	0.56	2.0	2.0	25.5
	June	0.008	0.015	0.131	0.010	0.69	1.7	3.0	29.3
	July	0.047	0.174	1.415	0.069	4.04	8.1	14.4	29.3
	September	0.055	0.173	1.380	0.075	4.89	8.6	15.0	27.9
	December	0.099	0.435	3.195	0.152	10.27	17.0	22.0	14.3
1976	February	0.053	0.235	1.604	0.076	4.98	8.8	13.2	19.5

Apron Bottom

	Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974	October	0.252	0.600	3.330	0.242	8.37	16.1	25.0	23.8
1975	February	--	--	--	--	--	7.4	9.8	13.8
	March	0.119	0.355	2.589	0.103	6.20	8.4	11.8	16.1
	April	0.036	0.068	0.575	0.036	1.309	4.3	5.4	22.5
	May	0.011	0.019	0.144	0.010	0.54	2.0	1.9	25.4
	December	0.124	0.480	3.588	0.163	10.38	19.3	24.2	14.0
1976	February	0.055	0.190	1.297	0.065	10.4	8.8	13.3	19.5

Channel Bottom

	Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974	October	0.252	0.730	4.650	0.282	10.66	22.0	--	--
1975	February	0.265	1.110	7.950	0.346	15.66	27.0	--	--
	March	0.185	0.905	6.900	0.284	14.87	22.0	--	--
	April	0.068	0.142	1.012	0.055	2.48	6.0	7.5	20.8
	May	0.142	0.493	4.106	0.220	15.62	28.0	38.6	25.1
	June	0.085	0.292	2.339	0.105	6.10	12.5	18.6	28.5
	July	0.152	0.438	3.036	0.185	11.74	20.5	30.0	29.8
	September	0.106	0.339	2.463	0.138	10.95	20.0	33.9	27.2
	December	0.148	0.441	3.347	0.186	14.10	27.0	35.6	14.4
1976	February	0.089	0.271	2.001	0.126	9.34	18.0	20.7	17.5

Appendix 6. Water physicochemical parameters at station 6.

Surface

Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974 June	0.152	0.350	2.140	0.117	4.66	11.6	19.3	25.9
October	0.152	0.540	3.430	0.156	7.28	12.8	19.8	22.7
December	0.060	0.185	1.180	0.094	2.54	7.6	9.8	12.6
1975 February	0.205	0.660	4.968	0.211	11.93	19.2	24.8	15.0
April	0.050	0.125	1.035	0.048	2.09	5.0	6.5	22.1
May	0.021	0.053	0.449	0.023	1.12	3.0	3.9	25.9
June	0.019	0.044	0.362	0.023	1.27	2.4	4.6	29.4
September	0.107	0.260	2.225	0.113	6.82	12.7	21.4	27.4
December	0.107	0.328	2.450	0.137	10.79	17.5	22.5	14.5
1976 January	0.078	0.348	2.829	0.127	10.20	16.5	19.3	10.0

Apron Bottom

Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974 June	0.180	0.480	3.080	0.156	6.04	12.5	20.4	25.5
October	0.168	0.500	3.960	0.172	7.53	13.7	20.9	22.4
December	0.096	0.315	1.630	0.117	4.24	7.6	10.1	12.8
1975 February	0.216	0.800	6.210	0.241	12.20	16.1	21.0	15.1
April	0.053	0.118	1.012	0.051	1.97	5.0	6.8	22.0
May	0.027	0.066	1.001	0.033	1.83	4.0	6.2	25.6
June	0.026	0.047	0.385	0.028	1.94	5.5	9.8	29.2
September	0.089	0.341	2.753	0.145	9.39	17.9	29.7	27.7
December	0.115	0.464	3.657	0.164	10.61	18.0	22.7	13.5
1976 January	0.106	0.344	2.829	0.145	10.2	16.2	18.9	9.9

Channel Bottom

Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974 October	0.272	0.840	5.200	0.289	10.32	22.0	--	23.4
December	0.260	0.870	5.630	0.336	11.77	27.5	--	--
1975 February	0.216	0.840	6.440	0.246	12.71	17.3	26.7	15.3
April	0.122	0.342	2.668	0.125	6.26	12.5	16.3	20.8
May	0.192	0.545	3.450	0.255	14.07	26.0	38.3	25.3
June	0.083	0.307	2.691	0.119	7.96	15.5	23.4	28.6
September	0.117	0.480	3.485	0.174	11.59	22.0	37.4	27.0
December	0.142	0.503	3.830	0.212	14.17	27.0	25.6	14.1
1976 January	0.096	0.307	2.553	0.142	11.00	18.5	32.8	10.4

Appendix 7. Water physicochemical parameters at station 7.

Surface

	Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974	June	0.312	1.080	5.680	0.336	11.50	25.0	39.8	26.6
	October	0.168	0.500	3.590	0.188	6.39	16.4	24.7	22.1
	December	0.196	0.630	4.050	0.281	6.13	18.6	23.0	13.0
1975	February	0.070	0.246	1.886	0.088	3.94	6.8	9.7	16.7
	March	0.250	0.788	6.072	0.289	11.21	20.2	26.8	16.5
	April	0.100	0.340	2.438	0.104	7.04	10.5	13.9	24.5
	May	0.132	0.356	2.950	0.147	8.44	15.5	22.6	26.2
	June	0.092	0.292	2.456	0.124	7.13	12.2	21.4	28.6
	July	0.173	0.427	3.002	0.186	11.34	19.2	32.2	29.4
	September	0.176	0.545	3.968	0.213	10.88	18.3	30.8	28.2
	December	0.118	0.438	3.174	0.166	11.29	18.4	22.5	12.4
1976	January	0.079	0.341	2.805	0.126	10.50	16.8	19.4	9.5
	February	0.081	0.286	2.120	0.113	8.22	13.7	19.8	19.1

Channel Bottom

	Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974	June	0.324	0.880	5.570	0.313	11.79	25.0	40.0	26.9
	October	0.200	0.680	3.520	0.266	8.06	17.3	26.0	22.4
	December	0.240	0.900	5.630	0.360	9.17	26.3	32.3	14.1
1975	February	0.270	1.170	8.418	0.407	17.30	27.8	36.0	17.0
	March	0.200	0.760	5.888	0.296	13.16	20.6	27.1	16.1
	April	0.126	0.320	2.346	0.156	7.07	12.5	16.3	21.0
	May	0.263	0.751	5.244	0.348	18.60	33.0	42.2	25.0
	June	0.094	0.267	2.225	0.142	7.27	15.0	20.3	--
	July	--	0.727	3.174	0.311	16.96	30.0	40.2	27.9
	September	0.147	0.361	2.588	0.172	11.04	22.0	38.7	27.3
	December	--	--	1.980	0.138	11.34	22.0	23.1	13.0
1976	January	0.094	0.396	2.708	0.150	11.4	17.5	33.4	10.6
	February	0.124	0.408	3.091	0.164	12.7	22.0	25.2	18.4

Appendix 8. Water physicochemical parameters at station 8.

Surface

	Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974	June	0.196	0.700	4.600	0.242	7.68	24.2	39.2	26.8
1975	February	0.205	0.573	4.554	0.229	9.43	19.5	--	16.5
	March	0.226	0.575	4.870	0.270	12.32	19.6	25.8	16.2
	July	0.190	0.588	4.140	0.203	10.93	16.8	29.3	30.8
	September	0.112	0.353	2.594	0.154	11.20	19.5	32.3	28.4
1976	February	0.101	0.352	2.318	0.125	8.72	14.7	20.9	18.4

Bottom

	Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1974	June	0.226	0.880	6.050	0.305	9.68	25.4	40.3	27.3
1975	February	0.310	1.200	8.740	0.430	18.70	30.0	--	16.7
	March	0.200	0.925	6.900	0.317	13.32	23.3	29.1	16.5
	July	0.216	0.713	4.913	0.328	18.32	32.0	43.9	27.6
	September	0.163	0.572	4.209	0.203	11.63	22.0	42.0	27.3
1976	February	--	--	4.692	0.250	15.90	30.0	33.0	17.4

Appendix 9. Water physicochemical parameters at station 9.

Month	Ca (‰)	Mg (‰)	Na (‰)	K (‰)	Cl (‰)	Sal. (‰)	Cond. (mmho)	Temp. (°C)
				Surface				
1974 December	0.034	0.080	0.477	0.022	0.99	3.3	4.2	12.4
1975 February	0.048	0.134	1.035	0.072	2.35	5.4	7.1	13.6
March	0.073	0.225	1.668	0.097	2.95	8.0	--	16.2
April	0.045	0.113	0.863	0.050	1.97	5.0	7.0	23.4
May	0.009	0.010	0.088	0.007	0.38	2.0	1.4	26.5
June	0.030	0.056	0.449	0.039	1.97	3.5	6.4	29.1
July	0.036	0.133	0.994	0.049	2.95	5.6	10.1	30.7
September	0.068	0.225	1.846	0.089	5.15	9.1	15.7	28.1
December	0.077	0.250	2.087	0.097	7.43	12.6	17.1	16.1
1976 January	0.070	0.263	2.191	0.105	8.29	13.8	16.7	11.1
February	0.053	0.203	1.415	0.069	4.77	8.2	12.6	20.3
				Bottom				
1974 December	--	--	--	--	--	3.5	4.6	12.5
1975 February	--	--	--	--	--	5.1	6.7	13.3
April	0.063	0.177	1.288	0.064	2.91	5.5	8.2	23.5
June	0.022	0.051	0.437	0.031	1.95	3.2	5.9	28.9
July	0.041	0.131	1.035	0.056	3.10	5.6	10.2	29.7
September	0.048	0.185	1.449	0.070	5.31	8.8	15.3	28.0
December	0.066	0.234	1.915	0.102	7.52	12.6	17.0	16.0
1976 January	0.091	0.256	2.122	0.101	8.08	11.9	14.8	11.3
February	0.047	0.193	1.311	0.068	4.83	8.3	12.4	20.6

Appendix 10. Water physicochemical parameters at station 10.

Surface

Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1975 February	0.068	0.215	1.679	0.082	3.26	5.9	8.4	16.5
March	0.170	0.635	4.876	0.210	9.74	17.5	23.4	16.1
April	0.078	0.279	2.139	0.104	4.06	8.5	11.5	22.5
May	0.100	0.414	4.575	0.113	6.63	15.0	20.3	25.9
June	0.086	0.297	2.439	0.129	7.93	14.0	23.9	29.0
July	0.074	0.222	1.880	0.085	5.45	9.6	17.5	30.9
September	0.091	0.327	1.742	0.090	5.75	10.3	17.3	26.9
December	0.102	0.438	3.278	0.152	10.68	17.4	22.2	14.1
1976 January	0.104	0.278	2.260	0.119	10.60	15.7	18.4	10.0
February	0.093	0.368	2.726	0.142	10.60	17.2	24.5	19.2

Bottom

Month	Ca	Mg	Na	K	Cl	Sal.	Cond.	Temp.
1975 February	--	--	--	--	--	6.1	8.5	16.3
March	--	--	--	--	--	17.9	23.7	16.2
April	0.070	0.203	1.541	0.078	3.68	8.5	13.5	22.5
May	0.098	0.290	2.450	0.125	7.73	15.0	21.9	25.6
June	0.102	0.327	2.743	0.130	7.94	11.9	20.8	29.6
July	0.068	0.205	1.673	0.084	5.55	10.2	18.4	30.4
September	0.094	0.256	2.122	0.096	6.20	10.9	18.3	27.3
1976 January	0.095	0.313	2.639	0.125	9.54	15.8	18.4	9.8
February	0.098	0.376	2.726	0.146	10.70	17.4	24.7	19.2

Appendix 11. Dissolved oxygen (p.p.m. = mg O_2/l).

Station	Position	1974			1975								1976	
		June	October	December	February	March	April	May	June	July	September	December	January	February
1	S	6.12	7.32	6.52	9.27	8.42	6.51	5.78	6.59	3.49	5.80	7.56	8.56	8.44
	B	5.88	0.00	6.33	7.92	8.42	6.32	5.68	6.89	3.39	5.61	7.46	7.13	8.24
2	S	6.60	5.65	6.04	--	--	--	--	--	--	--	--	--	--
	C	0.00	3.32	5.65	--	--	--	--	--	--	--	--	--	--
3	S	5.07	6.62	7.21	7.34	9.54	6.13	5.00	5.99	7.29	4.96	8.54	9.27	7.56
	B	--	5.46	--	--	--	6.13	2.84	--	--	3.74	6.50	9.15	7.46
	C	2.58	4.19	6.04	5.02	7.17	4.88	2.06	5.79	2.30	2.81	7.95	--	2.55
4	S	5.80	6.62	8.47	8.11	--	6.89	5.98	7.19	5.29	--	--	9.78	7.36
	B	--	--	--	7.73	--	7.09	5.59	7.39	3.79	--	--	--	7.26
	C	2.98	5.46	7.31	2.90	--	6.89	2.16	3.69	2.80	--	--	4.69	2.55
5	S	4.59	9.65	--	7.53	9.11	7.09	6.08	5.79	8.29	4.06	9.32	--	7.07
	B	--	9.16	--	--	8.81	7.18	5.68	--	--	--	9.32	--	7.07
	C	--	5.36	--	2.32	8.32	6.32	2.55	4.79	3.30	3.46	9.23	--	0.10
6	S	6.12	8.87	8.57	--	--	5.36	6.27	6.79	--	8.04	9.81	9.58	--
	B	5.88	8.66	8.37	--	--	7.09	5.49	6.29	--	6.17	9.23	9.58	--
	C	--	6.04	--	--	--	7.09	3.92	5.59	--	5.89	8.83	9.47	--
7	S	4.99	6.71	9.06	4.44	8.97	8.04	6.76	6.69	6.49	6.64	10.00	9.88	6.87
	C	4.59	7.21	8.08	5.02	8.77	7.66	3.04	6.89	0.30	6.64	9.91	9.58	7.56
8	S	5.31	--	--	6.38	9.01	--	--	--	7.69	6.45	--	--	8.54
	B	3.62	--	--	1.93	8.22	--	--	--	0.00	5.42	--	--	8.05
9	S	--	--	9.16	8.31	8.91	7.09	5.00	6.59	5.89	6.26	8.54	10.19	7.95
	B	--	--	--	--	--	7.09	--	6.49	5.79	6.17	8.44	9.98	7.75
10	S	--	--	--	10.05	9.21	8.23	5.10	6.19	8.09	7.11	6.87	9.98	7.85
	B	--	--	--	--	--	8.04	4.70	6.19	7.99	7.11	--	9.88	7.85

S = Surface Water

B = Bottom or Apron Bottom Water

C = Channel Bottom Water

Appendix 12. Dissolved oxygen - percent saturation.

Station	Position	1974 June	October	December	1975 February	March	April	May	June	July	September	December	1976 January	February
1	S	78	89	60	94	88	76	72	90	46	76	76	80	92
	B	70	0	73	78	88	71	70	93	45	73	78	70	89
2	S	86	73	56	--	--	--	--	--	--	--	--	--	--
	C	0	44	62	--	--	--	--	--	--	--	--	--	--
3	S	71	87	69	76	105	72	63	79	104	68	94	88	86
	B	--	71	--	--	--	72	36	--	--	51	70	101	85
	C	38	57	--	--	--	56	29	76	34	40	105	--	28
4	S	81	87	80	78	--	83	77	97	76	--	--	68	85
	B	--	--	--	--	--	86	71	98	--	--	--	--	84
	C	43	--	80	--	--	81	31	52	41	--	--	54	28
5	S	62	125	--	75	98	84	75	76	114	65	100	--	81
	B	--	118	--	--	94	85	70	--	--	--	101	--	81
	C	--	--	--	--	--	73	36	75	49	49	106	--	01
6	S	80	111	84	--	--	63	79	90	--	109	107	94	--
	B	76	108	83	--	--	83	69	85	--	88	98	93	--
	C	--	80	--	--	--	85	55	82	--	84	101	95	--
7	S	72	85	96	47	103	97	92	94	95	95	105	96	80
	C	66	92	92	61	100	92	44	--	05	95	107	96	91
8	S	76	--	--	73	104	--	--	--	114	93	--	--	100
	B	53	--	--	24	96	--	--	--	0	77	--	--	101
9	S	--	--	87	82	95	86	63	88	82	85	94	100	92
	B	--	--	--	--	--	86	--	86	79	84	92	98	90
10	S	--	--	--	106	104	100	68	87	116	95	74	97	94
	B	--	--	--	--	--	97	63	87	113	96	--	96	94

S = Surface Water

B = Bottom or Apron Bottom Water

C = Channel Bottom Water

Appendix 13. Macrofauna collected from the Calcasieu estuary. Higher taxa, common name (where known), method of collection (otter trawl-T, biological dredge-D, Petersen grab-G) and species code are given for each species.

Phylum Chordata
Class Chondrichthyes - [cartilaginous fishes]
Order Squaliformes
Family Carcharhinidae - Requiem sharks
78T Carcharhinus limbatus (Valenciennes) - Blacktip shark

Class Osteichthyes - [bony fishes]
Order Semionotiformes
Family Lepisosteidae - Gars
85T Lepisosteus osseus (Linnaeus) - Longnose gar
86T Lepisosteus spatula Lacepede - Alligator gar

Order Anguilliformes
Family Ophichthidae - Snake eels
83D,G Myrophis punctatus Lutken - Speckled worm eel
84D Echiophis punctifer (Kaup) - Stippled spoon-nosed eel

Order Clupeiformes
Family Clupeidae - Herrings
02T Brevoortia patronus Goode - Gulf menhaden
03T Dorosoma cepedianum (Lesueur) - Gizzard shad
04T Dorosoma petenense (Gunther) - Threadfin shad
06T Harengula pensacolae Goode and Bean - Scaled sardine
05T Opisthonema oglinum (Lesueur) - Atlantic thread herring
Family Ariidae - Sea catfishes
22T Arius felis (Linnaeus) - Sea catfish
21T Bagre marinus (Mitchill) - Gafftopsail catfish

Order Batrachoidiformes
Family Batrachoididae - Toadfishes
60T Porichthys porosissimus (Valenciennes) - Atlantic midshipman

Order Gobiesociformes
Family Gobiesocidae - Clingfishes
59T Gobiesox (?) punctulatus (Poey) - Stippled clingfish
67T Gobiesox strumosus Cope - Skilletfish

Order Gadiformes
Family Gadidae - Codfishes

62T *Urophycis floridanus* (Bean and Dresel) - Southern hake
63T *Urophycis regius* (Walbaum) - Spotted hake
Family Ophidiidae - Cusk eels and brotulas
64T *Ophidion welshi* (Nichols and Breder) - Crested cusk eel

Order Atheriniformes
Family Cyprinodontidae - Killifishes
69T *Fundulus grandis* Baird and Girard - Gulf killifish
Family Atherinidae - Silversides
77T *Menidia audens* Hay - Mississippi silverside
25T *Menidia beryllina* (Cope) - Tidewater silverside

Order Perciformes
Family Percichthyidae - Temperate basses
47T *Morone saxatilis* (Walbaum) - Striped bass
Family Centropomidae - Snooks
65T *Centropomus undecimalis* (Bloch) - Snook
Family Centrarchidae - Sunfishes
68T *Lepomis microlophus* (Gunther) - Redear sunfish
Family Carangidae - Jacks and Pompanos
38T *Caranx hippos* (Linnaeus) - Crevalle jack
36T *Chloroscombrus chrysurus* (Linnaeus) - Atlantic bumper
39T *Selar crumenophthalmus* (Bloch) - Bigeye scad
35T *Selene vomer* (Linnaeus) - Lookdown
37T *Trachinotus carolinus* (Linnaeus) - Florida pompano
34T *Vomer setapinnis* (Mitchill) - Atlantic moonfish
Family Gerreidae - Mojarras
70T *Eucinostomus argenteus* Baird and Girard - Spotfin mojarra
Family Pomadasyidae - Grunts
58T *Orthopristis chrysoptera* (Linnaeus) - Pigfish
Family Sparidae - Porgies
43T *Archosargus probatocephalus* (Walbaum) - Sheepshead
44T *Lagodon rhomboides* (Linnaeus) - Pinfish
Family Sciaenidae - Drums
17T *Bairdiella chrysoura* (Lacepede) - Silver perch
10T *Cynoscion arenarius* Ginsburg - Sand seatrout
12T *Cynoscion nebulosus* (Cuvier) - Spotted seatrout
11T *Cynoscion nothus* (Holbrood) - Silver seatrout
16T *Larimus fasciatus* Holbrook - Banded drum
08T *Leiostomus xanthurus* Lacepede - Spot
18T *Menticirrhus americanus* (Linnaeus) - Southern kingfish
07T *Micropogonias undulatus* (Linnaeus) - Atlantic croaker
09T *Pogonias cromis* (Linnaeus) - Black drum
13T *Stellifer lanceolatus* (Holbrook) - Stardrum
14T *Umbrina coroides* Cuvier - Sand drum
Family Ephippidae - Spadefishes
42T *Chaetodipterus faber* (Broussonet) - Atlantic spadefish
Family Mugilidae - Mullets
30T *Mugil cephalus* Linnaeus - Striped mullet
Family Polynemidae - Threadfins
27T *Polydactylus octonemus* (Girard) - Atlantic threadfin

Family Blenniidae - Combtooth blennies
80T *Hypleurochilus geminatus* (Wood) - Crested blenny
Family Eleotridae - Sleepers
46T *Dormitator maculatus* (Bloch) - Fat sleeper
Family Gobiidae - Gobies
31T *Gobionellus hastatus* Girard - Sharptail goby
79T *Gobiosoma*(?) *robustum* Ginsburg - Code goby
32T *Microgobius gulosus* (Girard) - Clown goby
Family Trichiuridae - Cutlass fishes
26T *Trichiurus lepturus* Linnaeus - Atlantic cutlass fish
Family Stromateidae - Butterfishes
28T *Peprilus alepidotus* (Linnaeus) - Harvest fish
29T *Peprilus burti* Fowler - Gulf butterfish
Family Triglidae - Searobins
72T *Prionotus rubio* Jordan - Blackfin searobin
71T *Prionotus tribulus* Cuvier - Bighead searobin

Order Pleuronectiformes
Family Bothidae - Lefteye flounders
48T *Citharichthys spilopterus* Gunter - Bay whiff
49T *Etropus crossotus* Jordan and Gilbert - Fringed flounder
52T *Paralichthys albigutta* Jordan and Gilbert - Gulf flounder
51T *Paralichthys lethostigma* Jordan and Gilbert - Southern flounder
82D *Trichopsetta ventralis* (Goode and Bean) - Sash flounder
Family Soleidae - Soles
56T *Trinectes maculatus* (Bloch and Schneider) - Hogchoker
Family Cynoglossidae - Tonguefishes
57T *Symphurus plagiusa* (Linnaeus) - Blackcheek tonguefish

Order Tetraodontiformes
Family Tetraodontidae - Puffers
75T *Sphoeroides*(?) *nephelus* (Goode and Bean) - Southern puffer
74T *Sphoeroides parvus* Shipp and Yerger - Least puffer

Class Acidiacea
Order Pleurogonia
Family Molgulidae
90T *Molgula* sp. - Sea squirt

Phylum Porifera
Class Demospongiae
Order Hadromerida
Family Clionidae
100D,G *Cliona* sp. - Boring sponge

Phylum Cnidaria
Class Hydrozoa
Order Hydrobida

Family Hydrathinidae
110D,G,T Cordylophora caspia (Pallas)
111D,G Hydractinia cf. echinata (Fleming) - Snail fur
Family Atratylidae
112G Bimeria franciscana Torrey
Family Camparularidae
113T Clytia coronata (Clarke)

Order Siphonophora
Family Physaliidae
120T Physalia physalis (Linnaeus) - Portuguese man-of-war

Class Scyphozoa
Order Rhizostomae
Family Stomolophidae
121T Stomolophus meleagris L. Agassiz - Cabbagehead

Order Semaeostomeae
Family Pelagidae
122T Chrysaora quinquecirrha (Desor) - Sea nettle

Class Anthozoa
Order Actiniaria
Family Actonostolidae
130T Paranthus rapiformis (Lesueur)
Family Aiptasidae
131T Aiptasia pallida (Verrill)
132T Haliplanella luciae (Verrill)

Order Madreporaria
Family Astraeidae
140T Astrangia solitaria Verrill - Solitary coral

Phylum Ctenophora
Class Tentaculata
Order Lobata
Family Mnemiidae
150T Mnemiopsis mccradyi Mayer - McCrady's comb jelly

Phylum Rhynchocoela
Class Nuda
Order Beroida
Family Beroidae
151T Beroe ovata Bosc - Beroe's comb jelly

Phylum Platyhelminthes
Class Turbellaria
Order Polycladidae

Family Stylochidae
160G,D,T *Stylochus ellipticus* (Girard) - Oyster leech

Class Anopla
Order Heteronemertea
Family Lineidae
170G *Micrura leidyi* Coe
171G *Cerebratulus lacteus* Verrill - Milky nemertean

Phylum Ectoprocta
Class Gymnolaemata
Order Cheilostomata
Family Membraniporidae
180G *Membranipora tenuis* (Desor)
Family Bugulidae
181G *Bugula* sp.

Phylum Annelida
Class Oligochaeta
Order Haplotaxida
Family Tubificidae
190G *Monopylephorus helobius* Loden
191G *Tubificoides heterochaetus* (Michaelsen)
192G,T *Tubificoides denouxi* Shirley and Loden
193G *Thalassodrilides belli* (Cook)
194G *Limnodriloides* sp.

Class Polychaeta
Order Cossurida
Family Cossuridae
200G *Cossura delta* Reish

Order Spionida
Family Spionidae
201G *Paraprionospio pinnata* (Ehlers)
202G,T *Polydora websteri* Hartman - Oyster worm
203G *Microspio* sp.

Order Capitellida
Family Capitellidae
204G *Mediomastus californiensis* Hartman
205G *Notomastus latericeus* Sars
206G *Capitella* cf. *capitata* (Fabricius)
Family Magelonidae
207G *Magelona pettiboneae* Jones

Order Phyllodocida
Family Phyllodocidae
208G *Phyllodoce* (=*Nereiphylla*) *fragilis* Webster

Family Polynoidae
209G *Lepidasthenia* sp.
Family Pilargiidae
210G,T *Parandalia fauveli* (Berkely and Berkely)
211G,T *Sigambra tentaculata* (Treadwell)
Family Nereidae
212G,T *Neanthes* (=*Nereis*) *succinea* (Frey and Leuckart) - Clam worm
Family Glyceridae
213G *Glycera* cf. *americana* Leidy

Order Amphinomida
Family Amphinomidae
214G *Paramphinome pulchella* Sars
215G *Pseudeurythoe ambigua* (Monro)

Order Eunicida
Family Onuphidae
216G,T *Diopatra cuprea* (Bosc) - Tube worm
Family Eunicida
217G,T *Marphysa sanguinea* (Montagu) - Blood worm
218G *Eunice* sp.
Family Lumbrineridae
219T *Lumbrineris branchiata* (Treadwell)

Order Flabelligerida
Family Flabelligeridae
219G *Pherusa* sp.

Order Terebellida
Family Pectinariidae
220G *Cistenides gouldii* Verrill - Ice cream cone worm
Family Ampharetidae
221G *Hobsonia florida* (Hartman) (=*Hypaniola floridana*)

Order Sabellida
Family Serpulidae
222G,D *Hydroides dianthus* (Verrill) - Tube worm

Class Hirudinea
Family Ichthyobdellidae
240T *Myzobdella lugubris* Leidy - Crab leech

Phylum Arthropoda
Class Crustacea
Subclass Cirripedia
Order Thoracica
Family Balanidae
250D *Balanus eburneus* Gould - Ivory barnacle
251D,T *Balanus improvisus* Darwin - Bay barnacle
252D,T *Balanus amphitrite amphitrite* Darwin - Little striped

barnacle
253D *Balanus subalbidus* Henry
254D,T *Chelonibia patula* (Ranzani) - Crab barnacle

Subclass Branchiura
Family Argulidae
255T *Argulus* sp. - Fish louse

Subclass Malacostraca
Order Stomatopoda
Family Squillidae
260T *Squilla empusa* Say - Mantis shrimp

Order Tanaidacea
Family Paratanaidae
270G *Leptochelia* sp.

Order Isopoda
Family Cymothoidea
285T *Anilocra acuta* (Richardson)
287T *Nirocila acuminata* (Schioedte and Meinert)
280T *Lironeca ovalis*
286T *Lironeca texana*
281T *Aegathoa oculata*
Family Idoteidae
282D *Edotea montosa* (Stimpson)
Family Sphaeromidae
283D *Cassidinidea ovalis* (Say)
284T *Sphaeroma terebrans* Bate

Order Amphipoda
Family Ampeliscidae
290G *Ampelisca* sp.
Family Corophiidae
291G,T *Corophium louisianum* (Shoemaker)
Family Melitidae
292G *Melita* sp.
Family Gammaridae
293D *Gammarus* sp.

Order Decapoda
Family Penaeidae
300T *Penaeus setiferus* (Linnaeus) - White shrimp

301T Penaeus aztecus Ives - Brown shrimp
302T Penaeus duorarum Burkenroad - Pink shrimp
303T Trachypenaeus similis (Smith) - Broken neck shrimp
304T Sicyonia dorsalis Kingsley - Rock shrimp
305T Xiphopenaeus kroyeri (Heller) - Sea bob
Family Sergestidae
306T Acetes americanus Ortmann - Net clinger
Family Ogyrididae
307T Ogyrides occidentalis (Ortmann) - Mud shrimp
Family Palaemonidae
308T Palaemonetes vulgaris (Say) - Common shore shrimp
309T Palaemonetes pugio Holthius - Grass shrimp
310T Palaemonetes intermedius Holthuis
311T Macrobrachium ohione (Smith) - River shrimp
Family Alpheidae
323T Alpheus armillatus Edwards
312T Alpheus heterochaelis Say - Big clawed snapping shrimp
Family Callianassidae
313T Gourretia latispina (Dawson) - Ghost shrimp
314G Callianassa jamaicense Schmitt
315G Callianassa islagrande Schmitt
Family Upogebiidae
316T Upogebia affinis (Say) - Flat browed mud shrimp
Family Diogenidae
317T,G,D Clibanarius vittatus (Bosc) - Striped hermit crab
Family Pagruidae
318T Pagurus pollicaris Say - Flat clawed hermit
319T Pagurus longicarpus Say
Family Portunidae
320T,D Callinectes sapidus Rathbun - Blue crab
321T,D Callinectes similis Williams
322D Portunus gibbesi (Stimpson)
Family Xanthidae
330T Panopeus herbstii Edwards
331T Panopeus bermudensis Benedict and Rathbun
332T Hexapanopeus angustifrons Benedict and Rathbun
333T Hexapanopeus paulensis Rathbun
334T,G Eurypanopeus depressus (Smith)
335T,G Rhithropanopeus harrisii (Gould) - Harris' mud crab
336T,G Menippe mercenaria (Say) - Stone crab
337G Micropanope sculptipes Stimpson
338G Neopanope texana (Stimpson)
Family Pinnotheridae
340T Pinnixia chacei Wass

Class Insecta
Order Diptera
Family Chironomidae
350G,T sp. A
351G,T sp. B

Phylum Mollusca
Class Gastropoda
Order Mesogastropoda
Family Hydrobiidae
360G *Probothynella protera* Pilsbury
Family Eptioniidae
361G *Epitonium rupicola* (Kurtz) - Brown-banded wendletrap
362G *Epitonium* sp.
Family Naticidae
370G,T *Polinices duplicatus* (Say) - Shark's eye

Order Neogastropoda
Family Columbellidae
371G *Anachis obesa* (Adams) - Fat dove shell
372G *Anachis avara* (Stearns) - Greedy dove shell
Family Nassariidae
373G *Nassarius vibex* (Say) - Common eastern nassa
374G *Nassarius acuta* (Say) - Sharp-knobbed nassa
Family Muricidae
375G,T *Thais haemastoma* (Lamarck) - Oyster drill
Family Pyramidellidae
376G *Littoridina sphinctosoma* Abbott and Ladd
377G *Odostomia gibbosa* Bush - Fat odostome
378G *Odostomia* cf. *laevigata* (d'Orbigny) - Smooth odostome
379G *Odostomia* cf. *bisurtalis* (Say)

Order Nudibranchia
Family Corambidae
380G,T *Doridella obscura* Verrill
Family Coryphellidae
381T ?*Coryphella* sp.

Class Pelecypoda
Order Prionodontida
Family Arcidae
390G,T *Anadara* cf. *transversa* (Say) - Transverse ark
Family Mytilidae
395G *Geukensia demissa* (Dillwyn) - Ribbed mussel
Family Mytilidae (continued)
396G,D,T *Ischadium recurvum* (Rafinesque) - Oyster mussel
397G *Amygdalum papyria* (Conrad) - Paper mussel
Family Ostreidae
398G,D,T *Crassostrea virginica* (Gmelin) - American oyster

Order Heterodontida
Family Dreissenidae
399G *Mytilopsis leucophaeata* (Conrad) - False mussel
Family Petricolidae
400G,T *Petricola pholadiformis* (Lamarck) - False angel wing
Family Mactridae

401G,T,D Rangia cuneata (Sowerby) - Common rangia
402G Rangia flexuosa (Conrad) - Brown rangia
403G,T Mulinia lateralis (Say) - Coot clam
404G Mulinia cf. ponchartrainensis Morrison
405G ?Spisula solidissima (Dillwyn) - Surf clam
Family Tellinidae
406G Tellina texana Dall - Say's tellin
407G Macoma mitchelli Dall - Mitchell's macoma
Family Solecurtidae
410G Tagelus plebius (Lightfoot) - Stout razor
Family Pholadidae
411G Barnea truncata (Say) - Fallen angel wing
412G,T Diplothyra smithii Tryon - Oyster piddock
413T Martesia cuneiformis (Say)
Family Teredinidae
415G Bankia gouldi Bartsch - Gould's shipworm

Class Cephalopoda
Order Teuthidida
Family Loliginidae
420T Lolliguncula brevis (Blainville) - Brief squid

Phylum Echindodermata
Class Ophiuroidea
Order Phrynophiurida
Family Gorgonocephalida
425T Astrophyton sp. - Basket star

Order Ophiruida
Family Amphiuridae
426T Hemipholas elongata (Say)

Phylum Hemichordata
Class Enteropneusta
Family Harrimaniidae
430G cf. Saccoglossus kowalevskii - Acorn worm

Phylum Phoronida
431G Phoronis architecta Andrews

Appendix 14. Attributes of community structure for assemblages collected by trawling at station 1. Values are presented as mean ± standard error of the mean.

Sampling Date	# Species	# Individuals	H'	J'	P.I.E.
June 1974	8	171	1.670	0.557	0.520
October	8	64	2.451	0.817	0.802
December	8	52	2.131	0.710	0.713
February 1975	6	40	1.830	0.780	0.633
March	9	325	0.602	0.190	0.158
April	9	326	0.865	0.273	0.242
May	6	181	1.273	0.493	0.424
June	9	244	0.714	0.225	0.186
July	12	241	1.715	0.478	0.553
September	9	103	2.325	0.734	0.735
December	12	159	1.973	0.550	0.576
January 1976	8	69	2.139	0.713	0.717
February	9	263	1.848	0.583	0.666
Mean	8.7±0.5	172.2±28.3	1.656±.169	0.541±.057	0.533±.060

Total species collected = 35 (22 fish, 13 invertebrates)

Total species unique to station 1 = 6

Appendix 15. Attributes of community structure assemblages collected by trawling at station 3. Values are presented as mean ± standard error of the mean.

Sampling Date	# Species	# Individuals	H'	J'	P.I.E.
June 1974	11	241	1.850	0.535	0.545
October	8	21	2.679	0.893	0.862
December	13	80	3.137	0.848	0.865
February 1975	2	6	0.650	0.650	0.333
March	9	228	1.169	0.369	0.377
April	14	397	2.494	0.655	0.742
May	9	941	0.617	0.195	0.165
June	10	691	1.609	0.484	0.549
July	3	15	1.159	0.731	0.514
September	4	38	1.719	0.859	0.679
December	7	88	1.215	0.433	0.412
January 1976	9	88	2.102	0.663	0.711
February	4	42	1.532	0.766	0.577
Mean	7.9±1.1	220.1±80.9	1.687±.211	0.623±.058	0.588±.066

Total species collected = 40 (27 fish, 13 invertebrates)

Total species unique to station 3 = 6

Appendix 16. Attributes of community structure for assemblages collected by trawling at station 4. Values are presented as mean ± standard error of the mean.

Sampling Date	# Species	# Individuals	H'	J'	P.I.E.
June 1974	3	41	0.978	0.617	0.398
October	12	1040	2.129	0.594	0.675
December	8	60	2.455	0.818	0.795
February 1975	12	123	2.644	0.738	0.800
April	16	837	1.833	0.458	0.566
May	12	422	2.425	0.676	0.762
June	20	900	2.092	0.484	0.649
July	5	72	1.698	0.731	0.642
January 1976	15	103	3.237	0.829	0.863
February	7	34	2.385	0.850	0.791
Mean	11±1.7	363.2±128.6	2.188±.192	0.679±.044	0.694±.044

Total species collected = 46 (26 fish, 20 invertebrates)

Total species unique to station 4 = 1

Appendix 17. Attributes of community structure for assemblages collected by trawling at station 5. Values are presented as mean ± standard error of the mean.

Sampling date	# Species	# Individuals	H'	J'	P.I.E.
June 1974	13	51	3.031	0.819	0.852
September	19	135	2.697	0.635	0.710
February 1975	5	43	1.572	0.677	0.551
March	10	439	1.261	0.380	0.431
April	14	989	1.995	0.524	0.687
May	17	435	2.606	0.638	0.778
June	13	374	2.492	0.673	0.751
July	12	490	1.209	0.337	0.364
September	8	466	0.447	0.149	0.112
December	6	31	1.772	0.685	0.654
February 1976	8	465	1.397	0.466	0.463
Mean	11.4±1.3	356.2±85.4	1.862±0.236	0.544±0.059	0.578±0.066

Total species collected = 48 (30 fish, 18 invertebrate)

Total species unique to station 5 = 5

Appendix 18. Attributes of community structure for assemblages collected by trawling at station 6. Values are presented as mean ± standard error of the mean.

Sampling Date	# Species	# Individuals	H'	J'	P.I.E.
June 1974	15	59	3.527	0.903	0.912
October	10	243	2.385	0.718	0.771
December	9	745	1.616	0.510	0.552
April 1975	16	413	1.440	0.360	0.432
May	10	729	2.326	0.700	0.752
June	12	176	2.244	0.626	0.676
September	9	86	1.844	0.582	0.616
December	6	267	1.080	0.418	0.461
January 1976	11	94	2.275	0.658	0.677
Mean	10.9±1.0	312.4±88.2	2.082±0.235	0.608±0.055	0.650±0.051

Total species collected = 35 (27 fish, 8 invertebrates)

Total species unique to station 6 = 1

Appendix 19. Attributes of community structure for assemblages collected by trawling at station 7. Values are presented as mean ± standard error of the mean.

Sampling Date	# Species	# Individuals	H'	J'	P.I.E.
June 1974	11	44	2.740	0.792	0.810
October	17	435	2.020	0.494	0.571
December	18	420	1.054	0.253	0.251
February 1975	13	514	0.822	0.222	0.204
March	19	390	2.447	0.576	0.693
April	17	359	1.913	0.468	0.547
May	18	1307	1.614	0.387	0.467
June	21	257	3.070	0.699	0.809
July	14	115	2.078	0.546	0.582
September	28	706	2.126	0.442	0.647
December	9	95	2.110	0.666	0.667
January 1976	13	114	3.025	0.818	0.862
February	17	4163	0.287	0.070	0.062
Mean	16.5±1.3	686.1±304.2	1.946±0.231	0.495±0.062	0.552±0.068

Total species collected = 81 (39 fish, 42 invertebrates)

Total species unique to station 7 = 16

Appendix 20. Attributes of community structure for assemblages collected by trawling at station 8. Values are presented as mean ± standard error of the mean.

Sampling Date	# Species	# Individuals	H'	J'	P.I.E.
June 1974	1	2	0	0	0
February 1975	1	3	0	0	0
March	18	419	2.552	0.612	0.779
July	2	27	0.918	0.918	0.461
September	13	142	2.679	0.724	0.802
February 1976	17	1133	1.799	0.440	0.589
Mean	8.7±3.4	287.7±181.1	1.325±0.491	0.449±0.156	0.439±0.148

Total species collected = 31 (18 fish, 13 invertebrates)

Total species unique to station 8 = 1

Appendix 21. Attributes of community structure for assemblages collected by trawling at station 9. Values are presented as mean ± standard error of the mean.

Sampling Date	# Species	# Individuals	H'	J'	P.I.E.
December 1974	11	219	1.092	0.316	0.327
February 1975	6	166	1.139	0.440	0.403
March	9	65	2.540	0.801	0.788
April	10	431	1.424	0.429	0.425
May	10	512	1.092	0.329	0.300
June	17	362	2.823	0.691	0.812
July	13	393	2.039	0.551	0.627
September	10	367	0.786	0.237	0.209
December	11	228	1.825	0.527	0.546
January 1976	4	23	0.765	0.383	0.249
February	6	265	0.547	0.211	0.163
Mean	9.7±1.1	275.5±46.3	1.461±0.226	0.447±0.055	0.441±0.068

Total species collected = 40 (27 fish, 13 invertebrates)

Total species unique to station 9 = 1

Appendix 22. Attributes of community structure for assemblages collected by trawling at station 10. Values are presented as mean ± standard error of the mean.

Sampling Date	# Species	# Individuals	H'	J'	P.I.E.
February 1975	8	99	2.115	0.705	0.685
March	8	243	1.934	0.645	0.667
April	6	596	0.203	0.078	0.046
May	15	630	2.957	0.757	0.831
June	20	735	2.626	0.608	0.762
July	12	464	2.110	0.589	0.633
September	7	53	1.146	0.408	0.340
December	11	32	3.043	0.870	0.880
January 1976	7	42	2.251	0.802	0.768
February	23	1232	1.717	0.379	0.544
Mean	11.7±1.9	412.6±124.6	2.010±0.269	0.585±0.076	0.616±0.080

Total species collected = 46 (25 fish, 21 invertebrates)

Total species unique to station 10 = 1

Appendix 23. Composition of trawl samples by date at station 1.

Species	74 Jun	Oct	Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Jan	Feb
Anchoa mitchilli	116	0	22	23	8	6	9	6	52	47	101	28	109
Archosargus probatocephalus	0	0	3	0	0	0	0	0	0	0	0	0	0
Arius felis	0	0	0	0	12	0	1	0	1	0	0	0	0
Balanus improvisus	0	10	0	0	0	0	0	0	0	0	0	0	0
Brevoortia patronus	8	0	0	0	0	0	22	220	1	0	0	0	0
Callinectes sapidus	0	3	4	0	3	0	1	5	1	0	7	2	0
Caranx hippos	0	0	0	0	0	0	0	0	2	0	0	0	0
Chironomid A	0	0	0	0	0	0	0	1	0	0	0	0	0
Chironomid B	0	0	0	0	0	0	0	0	0	0	0	0	1
Citharichthys spilopterus	0	0	0	0	0	0	0	0	1	0	0	0	0
Corophium louisianum	0	0	0	0	0	0	0	3	0	0	0	0	0
Cynoscion arenarius	1	0	0	0	0	0	0	0	0	0	0	0	0
Dorosoma cepedianum	1	0	1	4	11	0	0	0	0	7	0	0	0
Dorosoma petenense	14	0	1	4	3	0	0	0	0	0	0	1	2
Fundulus grandis	0	0	0	0	0	1	0	0	0	0	0	0	0
Gobiosoma robustum	0	0	0	0	0	0	0	0	1	1	1	0	0
Ictalurus furcatus	16	0	2	4	1	6	0	3	8	18	8	23	10
Leiostomus xanthurus	4	0	1	0	0	2	2	0	3	9	1	1	1
Lepisosteus osseus	0	0	0	1	0	0	0	0	0	0	0	0	0
Lepisosteus spatula	0	0	0	1	1	0	0	0	0	0	0	0	0
Lepomis microlophus	0	0	0	0	0	1	0	0	0	0	0	0	0
Macrobrachium ohione	0	0	0	0	0	21	0	1	0	0	0	0	0
Martesia cuneiformis	0	0	0	0	0	0	0	0	0	0	0	0	100
Micropogonias undulatus	11	1	17	7	298	283	135	1	152	5	18	5	36
Mytilopsis leucophaeata	0	16	0	0	0	0	0	8	0	0	2	0	0
Neanthes succinea	0	2	0	0	0	0	0	0	0	0	0	0	0
Ophidion welshi	0	0	0	0	0	0	1	0	0	0	0	0	0
Opisthonema oglinum	0	0	0	0	0	0	0	0	0	0	7	0	0
Penaeus aztecus aztecus	0	0	4	0	0	0	0	0	0	0	0	0	0
Penaeus setiferus	0	18	1	0	1	3	0	0	0	14	12	2	3
Pogonias cromis	0	0	0	0	0	0	0	0	0	1	0	0	0
Polydactylus octonemus	0	0	0	0	0	0	0	0	14	0	0	0	0
Rhithropanopeus harrisii	0	1	0	0	1	0	0	0	0	0	1	0	0
Sphaeroma terebrans	0	13	0	0	0	0	0	0	0	0	4	0	0
Trichiurus lepturus	0	0	0	0	0	0	0	0	1	0	0	0	0

Appendix 24. Composition of trawl samples by date at station 3.

Species	74 Jun	Oct	Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Jan	Feb
Aegathoa oculata	0	0	3	1	0	0	0	0	0	0	0	0	0
Anchoa mitchilli	159	0	8	0	177	40	29	36	0	9	66	1	26
Anilocra acuta	0	0	3	0	0	0	0	0	0	0	0	0	0
Arius felis	0	4	0	0	1	0	0	0	1	2	0	0	0
Balanus subalbidus	0	0	0	0	0	0	0	0	4	0	0	0	0
Brevoortia patronus	1	1	9	0	0	12	859	166	0	0	0	0	6
Callinectes sapidus	0	1	2	5	5	8	1	0	0	0	1	0	0
Caranx hippos	0	0	0	0	0	0	0	21	0	0	0	0	0
Centropomis undecimalis	0	0	0	0	0	0	0	2	0	0	0	0	0
Citharichthys spilopterus	0	0	0	0	0	0	0	0	0	0	1	0	0
Cynoscion arenarius	0	0	0	0	0	7	0	2	0	0	0	0	0
Cynoscion nebulosus	0	0	1	0	0	0	0	0	0	0	0	4	0
Dorosoma cepedianum	0	0	18	0	2	0	0	0	0	0	0	38	0
Dorosoma petenense	26	5	0	0	1	4	0	0	0	0	0	0	0
Hexapanopeus paulensis	1	5	0	0	0	5	0	0	0	0	0	0	0
Ictalurus furcatus	0	0	0	0	0	1	0	3	0	0	0	0	0
Leiostomus xanthurus	14	1	19	0	0	111	6	431	10	9	2	24	3
Lepisosteus spatula	0	0	2	0	0	0	0	0	0	0	0	0	0
Lepomis microlophus	0	0	0	0	0	1	0	0	0	0	0	0	0
Menidia audens	3	0	0	0	0	0	0	0	0	0	0	0	0
Menidia beryllina	0	0	0	0	0	0	0	3	0	0	0	0	0
Microgobius gulosus	0	0	0	0	0	0	0	0	0	0	0	1	0
Micropogonias undulatus	4	0	6	0	33	161	29	0	0	0	15	16	7
Morone saxatilis	0	0	0	0	0	0	10	0	0	0	0	0	0
Mugil cephalus	6	0	0	0	0	0	0	0	0	0	0	2	0
Mytilopsis leucophaeata	16	0	0	0	0	0	0	0	0	0	0	0	0
Myzobdella lubugris	0	0	0	0	0	0	5	0	0	0	0	0	0
Neanthes succinea	2	0	0	0	2	0	0	0	0	0	0	0	0
Opisthonema oglinum	0	0	6	0	0	0	0	0	0	0	0	0	0
Palaemonetes pugio	0	0	0	0	0	5	0	2	0	0	0	0	0
Penaeus aztecus aztecus	0	0	0	0	0	11	0	0	0	0	0	0	0
Penaeus setiferus	0	3	2	0	6	26	1	0	0	18	2	0	0
Peprilus burti	0	0	0	0	1	0	0	0	0	0	0	0	0

Appendix 24. Composition of trawl samples by date at station 3 (continued).

Species	74 Jun	Oct	Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Jan	Feb
Pogonias cromis	0	0	1	0	0	0	0	0	0	0	0	1	0
Rhithropanopeus harrisii	0	0	0	0	0	5	0	0	0	0	0	0	0
Sphaeroma terebrans	9	0	0	0	0	0	0	0	0	0	0	0	0
Stellifer lanceolatus	0	0	0	0	0	0	0	25	0	0	0	0	0
Trinectes maculatus	0	0	0	0	0	0	1	0	0	0	0	1	0
Umbrina coroides	0	1	0	0	0	0	0	0	0	0	0	0	0
Urophycis regius	0	0	0	0	0	0	0	0	0	0	1	0	0

Appendix 25. Composition of trawl samples by date at station 4.

Species	74 Jun	Oct	Dec	75 Feb	Apr	May	Jun	Jul	76 Jan	Feb
Acetes americanus	0	34	0	33	0	0	0	0	0	0
Aegathoa oculata	0	0	0	1	0	0	0	0	21	0
Anadara transversa	0	0	0	0	0	0	7	0	0	0
Anchoa mitchilli	8	253	0	0	12	1	141	20	6	0
Archosargus probactocephalus	0	0	3	2	0	0	1	0	0	0
Arius felis	0	92	0	0	0	4	5	37	0	0
Bagre marinus	0	1	0	0	0	0	0	0	0	0
Balanus improvisus	0	0	0	0	525	0	0	0	0	0
Brevoortia patronus	0	0	3	1	1	0	494	0	0	0
Callinectes sapidus	0	0	16	16	3	76	2	0	4	6
Caranx hippos	0	0	0	0	0	0	0	11	0	0
Chaetodipterus faber	0	9	0	0	0	0	0	1	0	0
Chloroscombrus chrysurus	0	6	0	0	0	0	0	0	0	0
Citharichthys spilopterus	0	0	0	0	0	1	0	0	0	0
Crassostrea virginica	0	0	0	0	0	0	1	0	1	0
Cynoscion arenarius	0	26	0	1	23	23	13	0	0	0
Dormitator maculatus	0	0	1	0	0	0	0	0	0	0
Dorosoma petenense	0	0	0	4	0	0	1	0	2	0
Hexapanopeus paulensis	0	0	0	0	1	0	0	0	0	0
Ictalurus furcatus	0	0	0	0	0	0	0	0	0	1
Ischadium recurvum	0	0	0	0	16	0	17	0	0	0
Lagodon rhomboides	0	1	0	0	0	0	0	0	0	0
Leiostomus xanthurus	0	0	7	19	5	23	2	0	1	3
Macrobrachium ohione	0	0	0	0	2	17	1	0	0	0
Micropogonias undulatus	0	3	19	37	150	150	52	0	8	13
Mugil cephalus	0	0	1	3	0	0	0	0	1	0
Mytilopsis leucophaeata	0	0	0	0	0	0	7	0	5	0
Neanthes succinea	0	2	0	0	0	0	1	0	7	0
Ogyrides occidentalis	0	0	0	0	2	0	0	0	8	0
Opisthonema oglinum	0	0	0	4	0	0	1	0	2	0
Palaemonetes pugio	0	0	0	0	2	0	0	0	0	0
Palaemonetes vulgaris	0	0	0	0	2	0	0	0	7	0
Paralichthys lethostigma	0	0	0	0	0	0	0	0	0	1
Penaeus aztecus aztecus	2	0	0	0	21	114	134	0	0	0
Penaeus setiferus	0	61	0	0	0	0	0	0	0	0
Peprilus alepidotus	31	0	0	0	71	9	11	3	0	0
Pogonias cromis	0	0	10	0	0	1	0	0	2	6

Appendix 25. Composition of trawl samples by date at station 4 (continued).

Species	74 Jun	Oct	Dec	75 Feb	Apr	May	Jun	Jul	76 Jan	Feb
Polydactylus octonemus	0	0	0	0	0	0	1	0	0	0
Polydora websteri	0	0	0	0	0	0	0	0	28	0
Rhithropanopeus harrisii	0	0	0	0	1	0	0	0	0	0
Sphoeroides parvus	0	1	0	0	0	0	0	0	0	0
Stellifer lanceolatus	0	0	0	0	0	0	0	0	0	4
Trinectes maculatus	0	0	0	0	3	0	0	0	0	0

Appendix 26. Composition of trawl samples by date at station 5.

Species	74 Jun	Oct	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Feb
Anchoa mitchilli	5	70	28	85	285	98	54	386	439	11	66
Arius felis	1	9	0	0	7	2	1	6	8	0	0
Brevoortia patronus	6	1	2	320	0	1	165	60	0	0	0
Callinectes sapidus	1	14	0	1	14	16	1	0	0	0	0
Callinectes similis	0	8	0	0	0	0	0	0	0	0	0
Caranx hippos	0	0	0	0	0	0	2	0	0	0	0
Carcharinus limbatus	1	0	0	0	0	0	0	0	0	0	0
Chaetodipterus faber	0	1	0	0	0	0	0	2	1	0	0
Chelonibia patula	0	0	0	0	1	0	0	0	0	0	0
Chloroscombrus chrysurus	0	3	0	0	0	0	0	11	0	0	0
Clibanarius vittatus	0	1	0	0	0	0	0	0	0	0	0
Cynoscion arenarius	1	1	0	0	15	14	12	12	2	0	0
Cynoscion nothus	5	0	0	0	0	0	0	0	0	0	0
Dorosoma cepedianum	0	0	0	0	0	0	0	1	0	0	0
Dorosoma petenense	0	2	0	2	0	1	1	0	0	0	0
Hexapanopeus paulensis	0	0	0	0	0	2	0	0	0	0	0
Lagodon rhomboides	0	2	0	0	0	0	0	0	0	0	0
Larimus fasciatus	16	0	0	0	0	0	0	0	0	0	0
Leiostomus xanthurus	0	0	0	2	11	120	27	6	0	0	12
Lironeca ovalis	0	0	0	0	1	0	0	0	0	0	0
Lironeca texana	0	0	0	0	1	0	0	0	0	0	0
Lolliguncula brevis	4	1	0	0	0	0	0	0	0	0	0
Macrobrachium ohione	0	0	0	0	0	11	2	0	0	0	0
Menticirrhus americanus	0	2	0	0	0	0	0	0	0	0	0
Micropogonias undulatus	6	0	5	4	428	132	24	8	3	1	332
Mugil cephalus	0	0	6	0	0	0	0	0	0	0	0
Ogyrides occidentalis	0	0	0	0	0	2	0	0	0	0	0
Opisthonema oglinum	0	0	0	0	0	0	0	0	1	0	0
Palaemonetes intermedius	0	0	0	0	2	0	0	0	0	0	0
Palaemonetes pugio	0	0	0	0	0	2	0	0	0	0	0
Palaemonetes vulgaris	0	0	0	0	2	0	42	0	0	0	0
Paralichthys lethostigma	0	0	0	0	3	6	0	0	0	0	1
Penaeus aztecus aztecus	1	0	0	0	15	13	42	1	0	1	0
Penaeus setiferus	0	2	2	0	204	12	1	0	1	15	40
Peprilus alepidotus	1	0	0	0	0	0	0	6	0	0	0

Appendix 26. Composition of trawl samples by date at station 5 (continued).

Species	74 Jun	Oct	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Feb
Peprilus burti	1	0	0	7	0	0	0	0	0	0	0
Polydactylus octonemus	0	0	0	0	0	0	0	1	0	0	0
Prionotus tribulus	0	0	0	2	0	0	0	0	0	0	0
Rhithropanopeus harrisii	0	0	0	0	0	2	0	0	0	0	0
Selar crumenophthalmus	0	0	0	0	0	0	0	0	0	0	1
Sphoeroides nephelus	0	1	0	0	0	0	0	0	0	0	0
Sphoeroides parvus	0	0	0	1	0	0	0	0	0	0	0
Squilla empusa	0	1	0	0	0	0	0	0	0	0	0
Stellifer lanceolatus	0	7	0	15	0	0	0	0	0	0	5
Synodus foetens	0	1	0	0	0	0	0	0	2	0	0
Trachypenaeus similis	0	8	0	0	0	0	0	0	0	0	0
Trichiurus lepturus	0	0	0	0	0	1	0	1	0	0	0
Trinectes maculatus	0	0	0	0	0	0	0	0	0	1	0

Appendix 27. Composition of trawl samples by date at station 6.

Species	74 Jun	Oct	Dec	75 Apr	May	Jun	Sep	Dec	76 Jan
Anchoa mitchilli	0	62	471	7	259	91	49	178	3
Alpheus heterochaetus	0	0	0	1	0	0	0	0	0
Archosargus probatocephalus	0	0	0	1	0	0	0	0	0
Arius felis	7	79	0	0	3	0	9	0	0
Brevoortia patronus	1	0	128	12	131	6	0	0	0
Callinectes sapidus	7	2	5	2	6	1	2	2	16
Caranx hippos	0	0	0	0	0	3	0	0	0
Chaetodipterus faber	5	4	0	1	0	0	1	0	0
Chloroscombrus chrysurus	1	0	0	0	0	4	20	0	0
Citharichthys spilopterus	0	1	1	13	0	4	1	0	0
Cynoscion arenarius	2	27	7	0	7	9	1	2	0
Cynoscion nebulosus	0	0	0	1	0	0	0	0	4
Leiostomus xanthurus	0	0	0	2	48	2	0	0	6
Lolliguncula brevis	3	0	0	0	0	0	0	0	0
Menticirrhus americanus	0	2	0	0	0	0	0	0	0
Micropogonias undulatus	7	0	21	305	49	13	1	1	50
Opisthonema oglinum	1	0	11	0	0	0	0	0	0
Palaemonetes vulgaris	0	0	0	4	0	0	0	0	4
Paralichthys albigutta	0	0	0	0	0	0	0	0	3
Paralichthys lethostigma	0	0	0	1	0	0	0	0	0
Penaeus aztecus aztecus	5	0	0	1	207	39	0	0	0
Penaeus setiferus	0	53	100	60	13	0	2	83	2
Peprilus alepidotus	11	0	0	0	0	3	0	0	0
Pogonias chromis	0	0	0	0	0	0	1	0	0
Polydactylus octonemus	0	0	0	0	6	0	0	0	0
Prionotus rubio	0	0	0	0	0	0	0	0	1
Selene vomer	4	0	0	0	0	0	0	0	0
Sphoeroides parvus	0	0	0	1	0	0	0	0	0
Stellifer lanceolatus	2	7	0	0	0	0	0	0	0
Symphurus plagiusa	0	0	0	1	0	1	0	0	0
Trachinotus carolinus	1	0	0	0	0	0	0	0	0
Trachypenaeus similus	0	0	0	0	0	0	0	0	2
Trichiurus lepturus	0	0	1	0	0	0	0	0	0
Xiphopenaeus kroyeri	0	6	0	0	0	0	0	0	0

Appendix 28. Composition of trawl samples by date at station 7.

Species	74 Jun	Oct	Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Jan	Feb
Acetes americanus	0	0	0	0	0	1	1	99	0	0	0	0	0
Aegathoa oculata	0	0	1	0	0	0	0	0	0	0	0	0	0
Aiptasia pallida	0	0	0	0	20	0	0	0	0	0	0	0	0
Alpeus armillatus	0	0	0	0	0	0	0	0	0	1	0	0	0
Alpheus heterochaetus	0	0	0	0	0	0	1	0	0	0	0	0	0
Anadara transversa	0	0	0	0	0	0	0	0	0	0	0	12	0
Anchoa mitchilli	3	1	1	1	6	50	0	28	0	335	10	16	36
Arius felis	0	4	0	4	9	17	48	0	73	0	0	0	0
Astrangia solitaria	0	0	0	0	200	0	0	0	0	0	0	0	0
Bagre marinus	0	0	0	0	0	0	1	0	3	0	0	0	0
Bairdiella chrysura	0	0	0	0	0	0	0	0	1	0	0	0	1
Balanus amphitrite	0	0	0	0	0	0	0	0	0	0	0	1	0
Balanus improvisus	0	0	0	0	38	0	2	0	0	1	0	4	0
Brevoortia patronus	1	0	0	0	0	0	0	5	0	0	0	0	0
Callinectes sapidus	2	4	2	12	1	0	25	1	0	2	7	2	7
Callinectes similis	0	3	0	0	1	1	0	0	7	0	0	0	0
Caranx hippos	0	0	0	0	0	0	0	1	1	0	0	0	0
Chaetodipterus faber	2	35	0	1	2	13	1	31	1	31	0	0	1
Chelonibia patula	0	1	0	0	0	0	0	0	0	0	0	0	0
Chloroscombrus chrysurus	14	41	0	0	0	0	0	6	0	4	0	0	0
Citharichthys spilopterus	0	0	0	0	0	1	0	1	0	0	0	0	0
Clibanarius vittatus	0	1	4	0	8	0	5	0	0	10	2	0	0
Crassostrea virginica	0	0	0	0	0	0	0	0	0	4	0	0	0
Cynoscion arenarius	0	27	3	0	0	5	0	24	1	0	0	0	4
Cynoscion nebulosus	0	0	1	0	0	0	14	0	0	0	1	0	1
Diopatra cuprea	0	0	0	0	0	0	0	0	0	1	0	0	0
Diplothyra smithii	0	0	1	0	4	0	0	0	0	0	0	0	0
Dorosoma cepedianum	1	0	0	0	0	0	0	1	0	0	0	0	0
Dorosoma petenense	0	0	0	0	0	0	0	1	1	0	0	1	0
Eurypanopeus depressus	0	0	0	0	0	0	0	0	0	3	0	0	0
Gobiesox punctulatus	0	0	0	3	0	0	0	0	0	0	2	0	8
Gobiesox strumosus	0	0	5	0	0	0	0	0	0	0	0	0	4
Gobionellus hastatus	0	0	0	0	0	0	0	1	0	0	0	0	0
Haliplanella luciae	0	0	0	0	0	0	0	0	0	0	0	12	0
Harengula pensacolae	0	1	0	0	0	0	0	0	0	0	0	0	0

Appendix 28. Composition of trawl samples by date at station 7 (continued).

Species	74 Jun	Oct	Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Jan	Feb
Hexapanopeus paulensis	0	0	0	0	0	0	0	0	0	2	0	0	0
Hypleurochilus geminatus	0	0	0	0	0	0	0	0	0	0	0	0	1
Larimus fasciatus	0	1	0	0	0	0	0	11	0	0	0	0	3
Leiostomus xanthurus	1	0	1	0	0	1	2	2	0	0	0	0	6
Lironeca ovalis	0	0	1	0	0	1	2	1	0	0	0	0	0
Lolliguncula brevis	0	0	0	0	0	0	1	0	2	2	0	0	0
Marphysa sanguinea	0	0	0	0	0	0	0	0	0	1	0	0	0
Menippe mercenaria	0	0	0	0	0	0	0	0	0	1	0	0	0
Menticirrhus americanus	0	3	0	0	1	0	0	0	0	0	0	0	0
Micropogonias undulatus	1	1	11	458	67	235	581	11	8	0	51	0	4031
Micrura leidyi	0	0	0	0	0	0	0	0	0	2	0	0	0
Mogula sp.	0	0	0	0	0	0	0	0	0	0	0	1	0
Neanthes succinea	0	0	0	0	15	0	0	0	0	13	0	25	0
Ophidion welshi	0	0	0	0	0	0	0	0	0	0	0	0	1
Opisthonema oglinum	0	0	3	0	0	0	0	0	0	0	0	0	0
Pagurus longicarpus	0	0	0	0	0	0	0	0	0	3	0	0	0
Palaemonetes vulgaris	0	0	0	0	0	0	0	0	0	0	0	20	0
Paralichthys lethostigma	0	0	0	0	0	0	0	0	0	0	0	0	1
Panopeus bermudensis	0	0	0	0	2	0	0	0	0	4	0	0	0
Panopeus herstii	0	0	0	0	0	0	0	0	0	12	4	1	0
Parandalia fauveli	0	0	0	0	0	0	0	0	0	5	0	0	0
Penaeus aztecus aztecus	13	0	0	0	0	0	17	12	0	0	0	0	0
Penaeus setiferus	0	13	363	3	0	0	3	0	0	13	17	2	0
Peprilus alepidotus	3	0	0	0	0	0	0	2	1	0	0	0	0
Peprilus burti	0	0	0	0	1	3	0	0	0	0	0	0	0
Petricola pholadiformis	0	0	0	0	0	0	0	0	0	1	0	17	0
Polonices duplicatus	0	0	0	0	0	0	0	0	0	1	0	0	0
Polydactylus octonemus	0	0	0	0	0	10	94	14	11	0	0	0	0
Porichthys porosissimus	0	0	0	1	0	3	0	0	0	0	0	0	0
Selar crumenophthalmus	5	0	0	0	0	0	0	0	0	0	0	0	0
Selene vomer	3	0	0	0	0	0	0	0	0	0	0	0	0
Sigambra tentaculata	0	0	0	0	0	0	0	0	0	1	0	0	0
Squilla empusa	0	0	0	12	0	0	0	0	0	0	0	0	0

Appendix 28. Composition of trawl samples by date at station 7 (continued).

Species	74 Jun	Oct	Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Jan	Feb
Stellifer lanceolatus	0	278	0	1	0	14	11	0	0	0	0	0	1
Symphurus plagiusa	0	16	0	0	1	0	0	1	0	0	0	0	3
Thais haemastoma	0	0	0	0	12	0	0	0	0	1	0	0	0
Trachypenaeus similis	0	0	12	12	0	0	0	0	1	0	0	0	0
Trichiurus lepturus	0	0	5	1	1	2	1	2	0	0	1	0	0
Trinectes maculatus	0	0	1	0	0	0	0	0	0	0	0	0	0
Tubificoides denouxi	0	0	0	0	0	0	0	0	0	1	0	0	0
Umbrina coroides	0	0	0	0	0	1	0	0	0	0	0	0	0
Upogebia affinis	0	0	0	0	0	0	0	0	0	1	0	0	0
Urophycis floridanus	0	0	0	0	0	0	0	0	0	0	0	0	54
Urophycis regius	0	0	2	5	0	1	0	0	4	0	0	0	0
Vomer setapinnis	0	0	0	0	0	0	0	1	0	0	0	0	0
Xiphopenaeus kroyeri	0	0	3	0	1	0	0	0	0	250	0	0	0

Appendix 29. Composition of trawl samples by date at station 8.

Species	74 Jun	75 Feb	Mar	Jul	Sep	76 Feb
Acetes americanus	0	0	0	0	1	274
Anchoa hepsetus	0	0	0	0	43	0
Anchoa mitchilli	0	0	94	0	0	82
Arius felis	0	0	0	18	14	0
Bagre marinus	0	0	2	0	0	0
Brevoortia patronus	0	0	1	0	1	0
Callinectes sapidus	2	0	0	9	0	7
Callinectes similis	0	0	17	0	0	2
Clibanarius vittatus	0	0	0	0	0	1
Cynoscion arenarius	0	0	2	0	2	0
Cynoscion nothus	0	0	0	0	1	0
Etropus crossotus	0	0	1	0	0	0
Harengula pensacolae	0	0	0	0	39	0
Lironeca ovalis	0	0	0	0	0	1
Lolliguncula brevis	0	0	0	0	1	2
Menticirrhus americanus	0	0	1	0	0	0
Micropogonias undulatus	0	0	84	0	17	39
Penaeus aztecus aztecus	0	0	0	0	0	1
Penaeus setiferus	0	0	3	0	4	36
Peprilus burti	0	0	2	0	0	0
Porichthys porosissimus	0	0	1	0	0	1
Prionotus rubio	0	0	1	0	0	0
Sicyonia dorsalis	0	0	0	0	0	3
Squilla empusa	0	0	49	0	0	11
Stellifer lanceolatus	0	0	7	0	15	0
Symphurus plagiusa	0	0	9	0	0	0
Thais haemastoma	0	0	0	0	0	1
Trachypenaeus similis	0	0	143	0	2	666
Trichiurus lepturus	0	0	1	0	0	0
Urophycis floridanus	0	0	1	0	0	5
Xiphopenaeus kroyeri	0	0	0	0	2	1

Appendix 30. Composition of trawl samples by date for station 9.

Species	74 Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Jan	Feb
Acetes americanus	0	0	0	0	0	3	0	0	0	0	0
Aegathoa oculata	0	0	3	0	0	0	0	0	0	0	0
Anchoa mitchilli	25	125	23	0	0	60	225	326	150	20	1
Archosargus probactocephalus	0	0	0	0	0	0	0	0	0	0	1
Arius felis	0	0	0	4	18	6	72	0	20	0	0
Bagre marinus	0	0	0	0	0	0	3	3	0	0	0
Balanus improvisus	0	7	0	0	0	39	0	0	20	0	0
Brevoortia patronus	4	0	17	9	2	5	25	1	18	0	0
Callinectes sapidus	0	2	2	7	23	1	0	1	1	1	16
Chaetodipterus faber	0	0	0	1	0	0	0	0	0	0	0
Citharichthys spilopterus	3	0	0	0	2	0	0	0	0	0	0
Cynoscion arenarius	0	1	0	16	9	89	32	0	2	0	0
Cynoscion nebulosus	1	0	0	0	0	0	0	0	0	0	0
Dorosoma cepedianum	0	0	0	0	0	0	0	0	0	1	0
Dorosoma petenense	0	0	0	0	0	0	0	2	0	0	0
Etropus crossotus	1	0	0	0	0	0	0	0	0	0	0
Eucinostomus argenteus	1	0	0	0	0	0	0	0	0	0	0
Ischadium recurvum	0	0	0	0	0	3	0	0	0	0	0
Leiostomus xanthurus	0	0	0	0	7	0	3	9	1	0	0
Lepisosteus spatula	0	0	1	0	0	0	0	0	0	0	0
Macrobrachium ohione	0	0	0	3	0	6	0	0	0	0	0
Micropogonias undulatus	178	29	9	323	427	105	13	11	7	0	242
Mugil cephalus	2	0	0	0	0	0	0	0	0	0	0
Mytilopsis leucophaeata	0	0	0	0	0	6	0	0	4	0	0
Neanthes succinea	0	0	0	0	0	0	0	1	0	0	0
Palaemonetes vulgaris	0	0	0	28	0	0	0	0	0	0	0
Paralichthys lethostigma	0	0	0	1	1	0	0	0	0	0	0
Penaeus aztecus aztecus	0	0	0	0	5	25	5	0	0	0	0
Penaeus setiferus	0	0	3	39	18	4	11	12	4	1	4
Peprilus alepidotus	0	0	0	0	0	0	0	1	0	0	0
Peprilus burti	0	0	4	0	0	0	0	0	0	0	0
Pogonias cromis	1	0	0	0	0	1	1	0	0	0	0
Polydactylus octonemus	0	0	0	0	0	4	0	0	0	0	0

Appendix 30. Composition of trawl stations by date at station 9 (continued).

Species	74 Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Jan	Feb
Porichthys porosissimus	1	0	0	0	0	0	0	0	0	0	0
Rangia cuneata	0	0	0	0	0	1	1	0	0	0	0
Rhithropanopeus harrisii	0	1	0	0	0	0	0	0	0	0	0
Selene vomer	0	0	0	0	0	0	1	0	0	0	0
Symphurus plagiusa	2	0	0	0	0	0	0	0	0	0	0
Trichiurus lepturus	0	0	3	0	0	0	1	0	0	0	0
Urophycis floridanus	0	0	0	0	0	0	0	0	0	0	1

Appendix 31. Composition of trawl samples by date at station 10.

Species	74 Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Jan	Feb
Acetes americanus	0	0	0	0	0	7	0	0	0	0	0
Anchoa mitchilli	0	4	41	0	107	8	266	43	6	1	295
Archosargus probatocephalus	0	13	0	0	0	3	0	0	1	9	1
Arius felis	0	0	0	0	19	12	75	3	0	0	0
Bagre marinus	0	0	0	0	0	0	5	0	0	0	0
Bairdiella chrysura	0	0	0	0	1	0	9	0	0	0	0
Balanus improvisus	0	0	123	582	0	0	0	0	0	0	0
Brevoortia patronus	0	0	0	0	74	0	28	0	0	0	0
Callinectes sapidus	2	0	0	2	6	14	0	0	3	1	24
Callinectes similis	0	0	2	0	0	0	0	0	0	0	1
Chaetodipterus faber	0	0	0	0	3	21	0	0	0	0	2
Chelonibia patula	0	0	0	2	0	0	0	0	0	0	0
Chloroscombrus chrysurus	0	0	0	0	0	0	0	1	0	0	0
Citharichthys spilopterus	0	1	0	0	0	1	1	0	8	0	0
Clibanarius vittatus	0	0	0	0	0	0	0	1	1	0	0
Crassostrea virginica	0	0	0	1	0	0	0	0	0	0	0
Cynoscion arenarius	0	0	0	0	15	49	9	0	0	0	0
Larimus fasciatus	0	0	0	0	0	98	0	0	0	0	3
Leiostomus xanthrurs	0	0	0	0	16	1	6	0	2	15	15
Lironeca ovalis	0	0	0	0	0	4	0	0	0	0	0
Macrobrachium ohione	0	0	0	0	0	1	0	0	0	0	0
Microgobius gulosus	0	0	0	0	0	0	0	0	0	0	1
Micropogonias undulatus	0	51	52	0	122	169	19	0	3	11	776
Micrura leidyi	0	0	0	0	0	0	0	0	0	0	1
Mulinia lateralis	0	0	0	0	0	0	0	0	0	0	4
Neanthes succinea	0	0	0	0	0	0	0	0	1	0	1
Ophidion welshi	0	0	0	1	0	0	0	0	0	0	1
Orthopristis chrysoptera	0	0	0	0	0	1	0	0	0	0	0
Palaemonetes vulgaris	0	8	7	8	18	42	0	0	0	2	39
Panopeus herbstii	0	0	0	0	0	0	0	0	1	0	0
Paraprionospio pinnata	0	0	0	0	0	0	0	0	0	0	1
Penaeus aztecus aztecus	0	0	0	0	181	293	39	1	0	0	0
Penaeus setiferus	0	17	16	0	41	7	0	3	0	0	37

Appendix 31. Composition of trawl samples by date at station 10 (continued).

Species	74 Dec	75 Feb	Mar	Apr	May	Jun	Jul	Sep	Dec	76 Jan	Feb
Peprilus burti	0	0	1	0	0	0	0	0	0	0	1
Pogonias cromis	0	4	0	0	12	2	0	1	1	3	0
Polydactylus octonemus	0	0	0	0	13	0	0	0	0	0	0
Polydora websteri	0	0	0	0	0	0	0	0	5	0	1
Prionotus rubio	0	0	0	0	0	0	0	0	0	0	2
Rhithropanopeus harrisii	0	0	0	0	0	1	0	0	0	0	0
Stellifer lanceolatus	0	0	0	0	0	0	6	0	0	0	3
Symphurus plagiusa	0	1	0	0	0	0	0	0	0	0	3
Trachypenaeus similis	0	0	1	0	0	0	0	0	0	0	5
Trichiurus lepturus	0	0	0	0	2	0	0	0	0	0	0
Urophycis floridanus	0	0	0	0	0	0	0	0	0	0	15
Vomer setapinnis	0	0	0	0	0	0	1	0	0	0	0
Xiphopenaeus kroyeri	0	0	0	0	0	1	0	0	0	0	0

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PERSONAL INFORMATION

Date of Birth:	September 17, 1947
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Social Security Number:	451-74-4512
Marital Status:	Married, no children
Military Service:	U. S. Army, 1970-1971
Health:	Excellent

EDUCATION

B. S. - May, 1969; Texas A&I University, Kingsville, Texas
Major: Biology
Minor: Chemistry

M. S. - August, 1974; Texas A&I University, Kingsville, Texas
Major: Biology
Minor: Geology
Thesis: "The Echinoderms of Seven and One-Half Fathom Reef"
Major Professor: Dr. Allan H. Chaney

Ph. D. - December, 1982; Louisiana State University, Baton Rouge, Louisiana
Major: Zoology
Minor: Marine Science
Dissertation: "Spatial and Temporal Variations in Community Structure of the Demersal Macrofauna of a Subtropical Estuary"
Major Professor: Dr. William B. Stickle

POSITIONS HELD

1982 - Physiologist (GS-11), NOAA, NMFS, Auke Bay Laboratory, Auke Bay, Alaska, working with "Effects of petroleum contamination on post larval stages of king crab and pink shrimp"

1978-1981 - Instructor, Department of Zoology and Physiology, Louisiana State University, Baton Rouge, Louisiana

Courses taught: General Biology, Introductory Invertebrate Zoology, Introductory Vertebrate Zoology, Honor's Invertebrate Zoology

POSITIONS HELD

1974-1978 - Graduate Assistant, Department of Zoology and Physiology, Louisiana State University. Assisted in the following courses:

Marine Zoology	Introductory Invertebrate Zoology
Marine Communities	Advanced Invertebrate Zoology
Marine Ecology	Introductory Vertebrate Zoology
Experimental Embryology	Physiology of Estuarine Organisms

1974-1978 - Fellowship, Petroleum Refiner's Environmental Council of Louisiana (PRECOL), Department of Zoology and Physiology, Louisiana State University

1971-1973 - Graduate Assistant, Biology Department, Texas A&I University, Kingsville, Texas. Assisted in the following courses:
General Zoology
General Botany
Advanced Invertebrate Zoology

1971-1973 - Research Assistant for project entitled "Further Faunal Investigations of Seven and One-Half Fathom Reef," Biology Department, Texas A&I University, Kingsville, Texas

1970-1971 - U. S. Army; Rank at time of Honorable Discharge - Sargeant.

1969-1970 - Undergraduate Curator of Texas A&I University Invertebrate Collection; Ranger, U. S. National Park Service, Padre Island National Seashore, Texas

HONORS, AWARDS, GRANTS

Bronze Star, U. S. Army, Vietnam, September, 1971
Caesar Kleberg Wildlife Foundation Scholarship, 1971-1972, 1972-1973
Distinguished Student, Texas A&I University, 1972-1973
Grants from LSU Foundation - August, 1975; July, 1976; March, 1977; October, 1977
Gr t from LSU Student Government Association - June, 1975
Scudent Travel Grant, Association of Southeastern Biologists - April, 1977
NSF Research Proposal, "Biotic interactions in marine sands: community regulation of meiofauna and macrofauna," Fall, 1978, for $36,322.

Approved but not funded.

Office of Coastal Zone Management proposal, "Effects of South Louisiana crude oil intrusion on oysters and benthic food webs in a Louisiana estuary," for $119,817, Spring, 1980. Approved but not funded.

PUBLICATIONS

Shirley, T. C. 1974. Planes cyaneus Dana, 1852 (Decapoda, Grapsidae) from Padre Island, Texas: a new record for the Gulf of Mexico and the North Atlantic. Crustaceana 26(1): 107-108.

Shirley, T. C. 1974. The ophiuroids of Seven and One-Half Fathom Reef. Tex. J. Sci. 25: 120. (Abstract)

Shirley, T. C. 1974. Caprella andreae Mayer, 1890 (Crustacea: Amphipoda) from Padre Island, Texas. Tex. J. Sci. 26(3-4): 621.

Shirley, T. C. 1974. The echinoderms of Seven and One-Half Fathom Reef. Masters Thesis, Texas A&I University, Kingsville, Texas. 82 pp.

Shirley, T. C., G. J. Denoux and W. B. Stickle. 1975. Respiration studies of the marsh periwinkle Littorine irrorata. American Zoologist 15(3): 810. (Abstract)

Shirley, T. C. and A. M. Findley. 1977. Circadian rhythm of oxygen consumption in the marsh periwinkle, Littorina irrorata (Gastropoda). The ASB Bulletin 24(2): 86. (Abstract)

Shirley, T. C. 1977. The importance of echinoderms as prey of fishes of a sublittoral rock reef. American Zoologist 17(4): 840. (Abstract)

Pawson, D. L. and T. C. Shirley. 1977. Occurrence of the subgenus (Holothuria) in the Gulf of Mexico (Echinodermata: Holothuroidea). Proc. Biol. Soc. Wash. 90(4): 915-920.

Shirley, T. C. and W. B. Stickle. 1978. Spatial and temporal variations in macroinvertebrate community structure in a Louisiana estuary. American Zoologist 18(3): 597. (Abstract)

Shirley, T. C. and A. M. Findley. 1978. Circadian rhythm of oxygen consumption in the marsh periwinkle, Littorina irrorata (Say, 1822). Comp. Biochem. Physiol. 59A: 339-342.

Shirley, T. C., G. J. Denoux and W. B. Stickle. 1978. Seasonal respiration in the marsh periwinkle, Littorina irrorata. Biol. Bull. 154: 322-334,

PUBLICATIONS CONTINUED

McCorkle, S., T. C. Shirley and T. H. Dietz. 1978. Rhythms of activity and oxygen consumption in the common pond clam, Ligumia subrostrata (Say). American Zoologist 1(3(: 654. (Abstract)

McCorkle, S., T. C. Shirley and T. H. Dietz. 1979. Rhythms of activity and oxygen consumption in the common pond clam, Ligumia subrostrata (Say). Can. J. Zool. 57(10): 1960-1964.

Shirley, T. C. and M. S. Loden. 1980. Demography and ecology of oligochaetes in a Louisiana estuary. North American Benthological Society, Invited Symposium on Estuarine Oligochaetes, p. 18.

Stickle, W. B., T. C. Shirley and T. D. Sabourin. (in press) Patterns of nitrogen excretion in four species of echinoderms as a function of salinity. Proceedings of the International Echinoderm Conference, Sept. 13-17, 1981, Tampa, Florida, J. L. Lawrence (Ed.), Balkema Publishers.

Shirley, T. C. and W. B. Stickle. 1981. Metabolic accomodation to salinity acclimation by Leptasterias hexactis. Proceedings of the International Echinoderm Conference, J. L. Lawrence (Ed.), Balkema Publishers. (Abstract)

Shirley, T. C. and W. B. Stickle. 1981. The utility of different indices in assessing hyposmotic stress in an asteroid. American Zoologist 21(4): 1042. (Abstract)

Shirley, T. C. and M. S. Loden. 1982. The Tubificidae (Annelida, Oligochaeta) of a Louisiana estuary: ecology and systematics, with a description of a new species. Estuaries 5(1): 47-56.

Shirley, T. C. (in press) The importance of echinoderms as prey of fishes of a sublittoral rock reef. Texas A&I University Studies.

Shirley, T. C. and W. B. Stickle. 1982. Responses of Leptasterias hexactis (Echinodermata: Asteroidea) to low salinity. I. Survival, activity, feeding, growth and absorption efficiency. Mar. Biol. 69(2): 147-154.

Shirley, T. C. and W. B. Stickle. 1982. Responses of Leptasterias hexactis (Echinodermata: Asteroidea) to low salinity. II. Nitrogen metabolism, respiration and energy budget. Mar. Biol. 69(2): 155-163.

PRESENTATIONS AT MEETINGS

Texas Academy of Science: 1973
American Society of Zoologists: 1975, 1977, 1978, 1981
Petroleum Refiners Environmental Council of Louisiana: 1975, 1976, 1977
Gulf Estuarine Research Society: 1976, 1980
Association of Southeastern Biologists: 1978
Coastal Marsh and Estuaries Symposium: 1978
North American Benthological Society: 1980
International Echinoderm Conference: 1981

PROFESSIONAL SOCIETIES

American Association for the Advancement of Science
American Institute of Biological Sciences
American Microscopical Society
Association of Southeastern Biologists
Biological Society of Washington
The Crustacean Society
Ecological Society of America
Gulf Estuarine Research Society
Louisiana Academy of Science
North American Benthological Society
Sigma Xi
Texas Academy of Science

PROFESSIONAL FIELD EXPERIENCE

Member of scientific party aboard National Marine Fisheries Service R/V OREGON II, Cruise #51, May - June, 1974, investigating demersal fauna of the northern Gulf of Mexico.

Member of scientific party aboard Texas A&M University R/V GYRE, Cruise #77G10, September, 1977, investigating fauna of submerged banks and reefs in the Gulf of Mexico.

Member of Bahamas National Trust Expedition to southern Bahamas, April, 1977, investigating shallow water invertebrate fauna.

Member of University of Southwestern Louisiana Tropical Field Expedition I, to Yucatan and southern Gulf of Mexico, December, 1976 - January, 1977, investigating shallow water fauna.

Taxonomic consultant to Southwest Research Institute for "Ecological Investigations of Petroleum Production Platforms in the Central Gulf of Mexico," a project funded by the Bureau of Land Management, 1978 - 1979.

FOREIGN LANGUAGES

Reading proficiency in German and Spanish

EXAMINATION AND THESIS REPORT

Candidate: Thomas C. Shirley

Major Field: Zoology

Title of Thesis: Spatial and temporal variations in community structure of the demersal macrofauna of a subtropical estuary

Approved:

William B. Stickle Jr.

Major Professor and Chairman

William J. Pogue

Dean of the Graduate School

EXAMINING COMMITTEE:

H D Hoese

W J Harman

J P Wooding

J W Fleeger

Date of Examination:

September 15, 1982